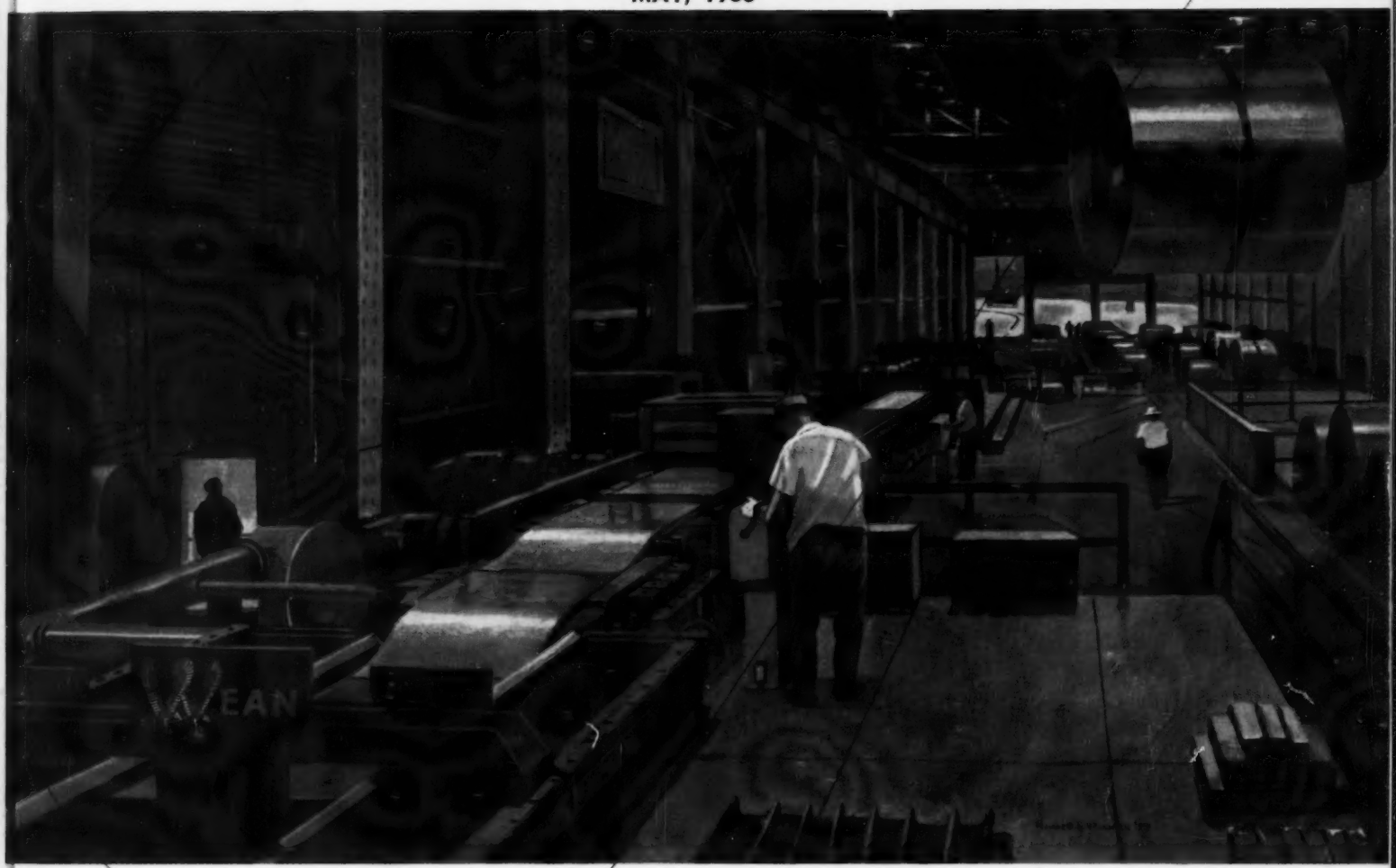
Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

MAY, 1960



No. 2 Cold Rolled Shearing Line, Cleveland Works, Jones & Laughlin Steel Corporation

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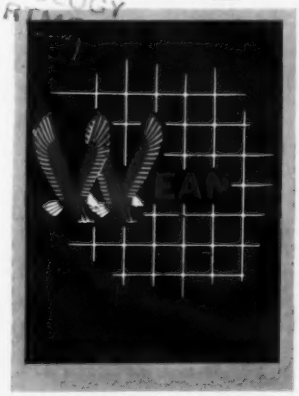
TECHNOLOGY DEPARTMENT

Wean, J & L and Shearing . . .

This precision-engineered line was designed by Wean for shearing cold rolled steel strip at the Cleveland Works of Jones & Laughlin Steel Corporation. This cold rolled shearing line handles 60,000 pound coils in strip widths up to 48″ and gauges from .025″ to .060″, producing leveled, oiled sheet from 30″ to 180″ in length. Speeds up to 800 fpm are possible through the use of improved design lapping conveyors on both prime and reject pilers.

Wean is the world's most experienced builder of steel strip processing lines. Our reserve of engineering know-how is always available to assist you in your expansion planning. To meet your customers' most exacting requirements, why not let Wean's *creative engineering* work for *you.*



THE WEAN ENGINEERING COMPANY, INC. • WARREN • OHIO

New! The most reliable limit switch ever developed

(from Cutler-Hammer, of course)

Limit switch failures cause more production down time than any other electrical component. Suddenly this problem has been greatly reduced by Cutler-Hammer's new oiltight limit switch. Under test conditions so tough they'd never be equalled in actual service, it lasted far longer than any other limit switch.

It fits almost anywhere and in any position. A simple field adjustment changes switch operation to close the contacts by lever motion that is clockwise, counterclockwise, or both. And, no other switch is sealed more effectively. Even the silver-to-silver contacts are visible for quick inspection. Send for Pub. ED143-J232 now for full details.

WHAT'S NEW AT CUTLER-HAMMER?

We're planning ahead—with new, *better* products, like the limit switch. We've added plant capacity, new engineering talent and our new trademark symbolizes our new capabilities to help you plan ahead. Call the nearest Cutler-Hammer sales office or distributor to see how we can fit into your team.

WHAT'S NEW? ASK...

CUTLER-HAMMER

CONTROL

Cutler-Hammer Inc., Milwaukee, Wisconsin • Division: Airborne Instruments Laboratory • Subsidiary: Cutler-Hammer International, C. A. Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.

What makes the difference between one galvanizing line and another? How can you save money on the purchase of a Continuous Galvanizing Line? What are the different components that must be considered in the designing of a line?

Aetna-Standard answers these and other questions in this new booklet on Continuous Galvanizing Lines. Other information includes information on the number of lines operating in the world; and pictures of different components of Continuous Galvanizing Lines.

A copy will be mailed promptly upon receipt of your request. BLAW-KNOX COMPANY, Aetna-Standard Division, Pittsburgh, Pennsylvania.

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THE WORLD'S LEADING DESIGNER AND BUILDER OF CONTINUOUS GALVANIZING LINES

Aetna-Standard Division
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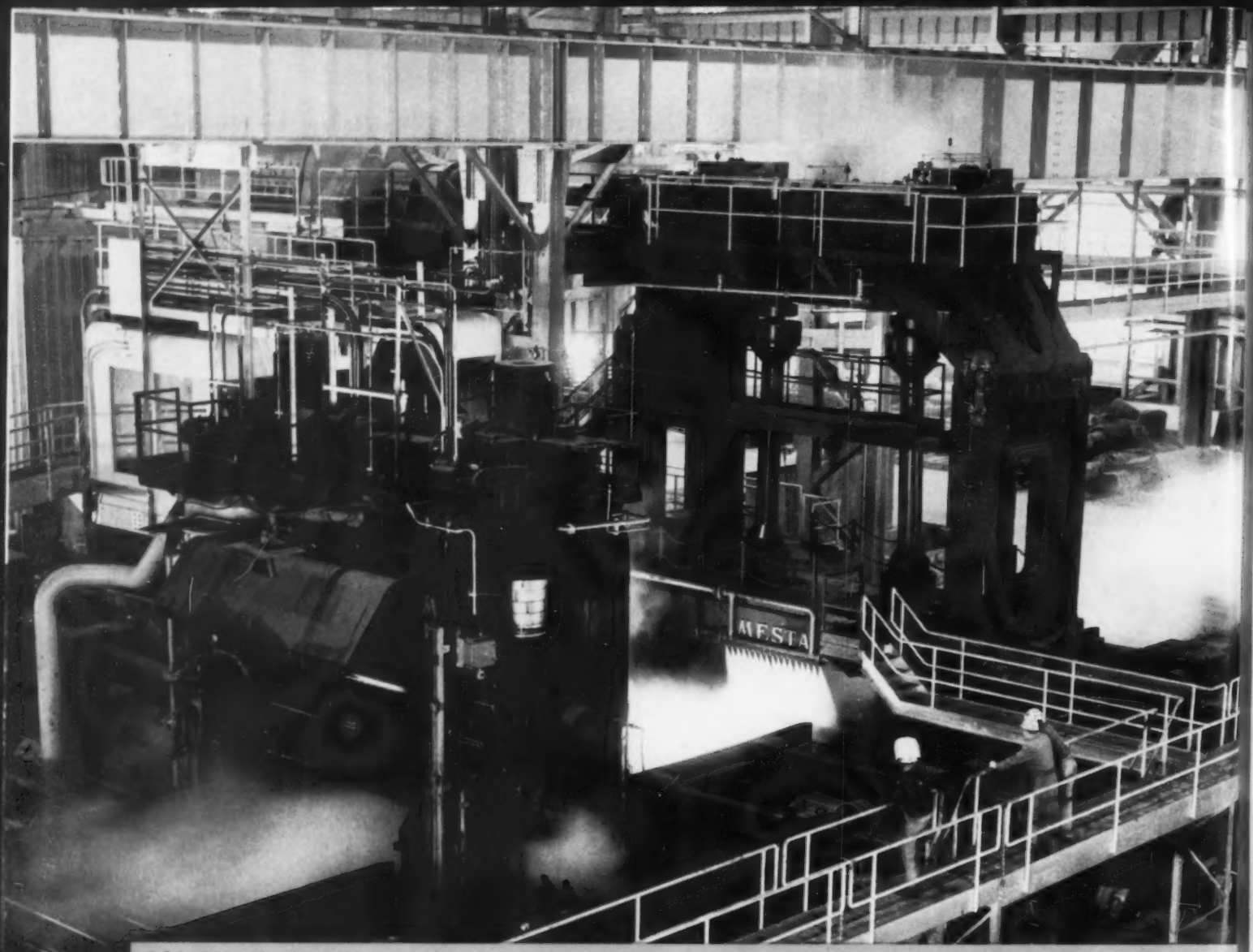
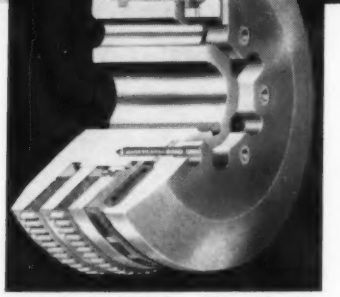


140 INCH MESTA SLABBING MILL WITH COMPACT, POWERFUL WICHITA CLUTCHES ON SCREW-DOWN SETS NEW WORLD STANDARD FOR LUKENS STEEL



Standard Air-Tube Disc Clutch

Outstanding feature of the horizontal mill is the screw-down drive with unique Wichita Clutches.

In place of conventional magnetic or mechanical clutches, are a pair of Wichita Air-Tube Disc Clutches . . . transmitting torques of 9,000 ft.-lbs. to run the screws down. The clutches are normally open and do not rely on electric current for normal mill operation. In addition, they are more compact than conventional clutches and offer many safety features.

For difficult or unusual clutching or braking problems it will pay you to call a Wichita Clutch engineer.

Contact your nearest Wichita Engineer.

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WICHITA Clutch COMPANY, INC.
WICHITA FALLS, TEXAS U.S.A.

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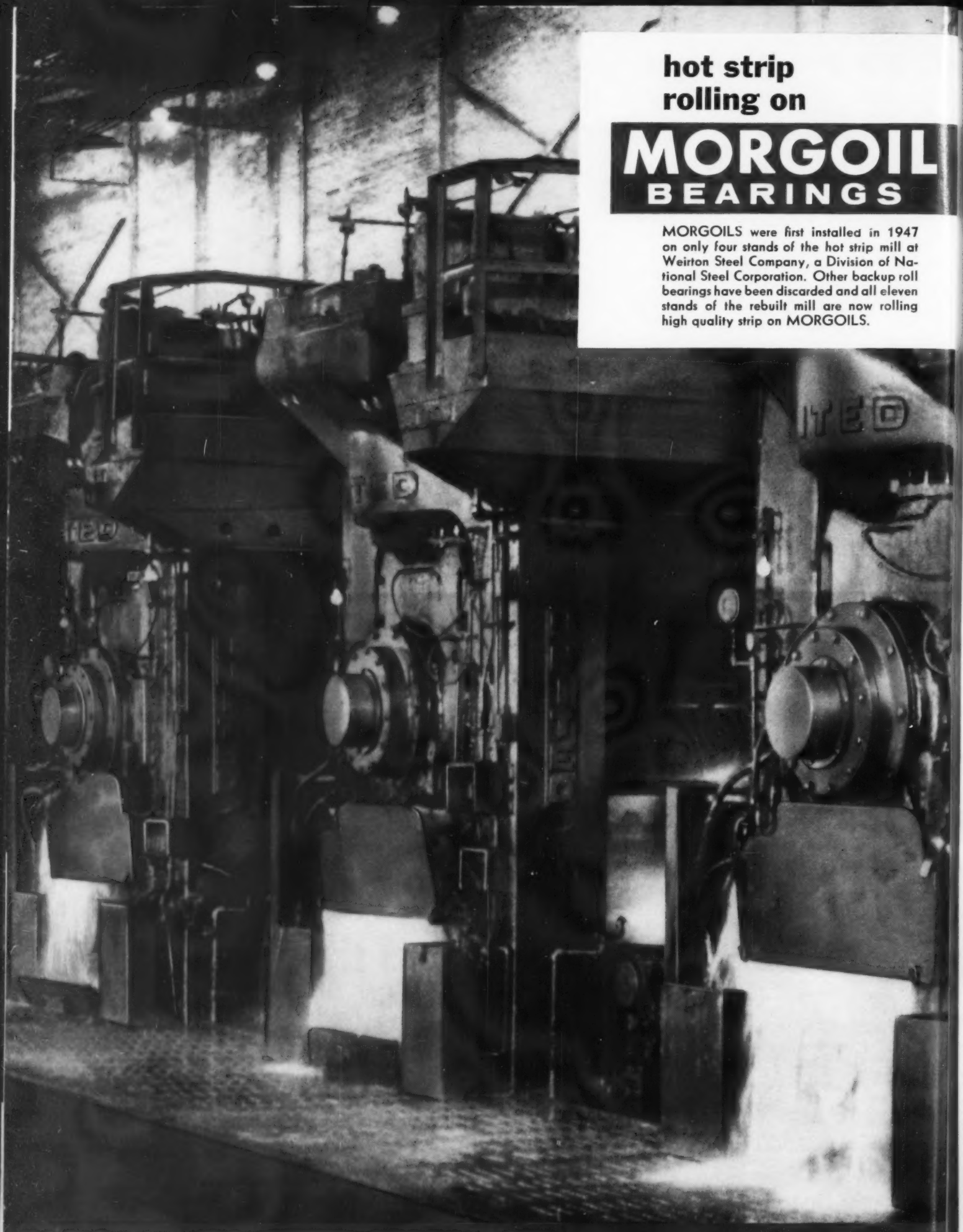


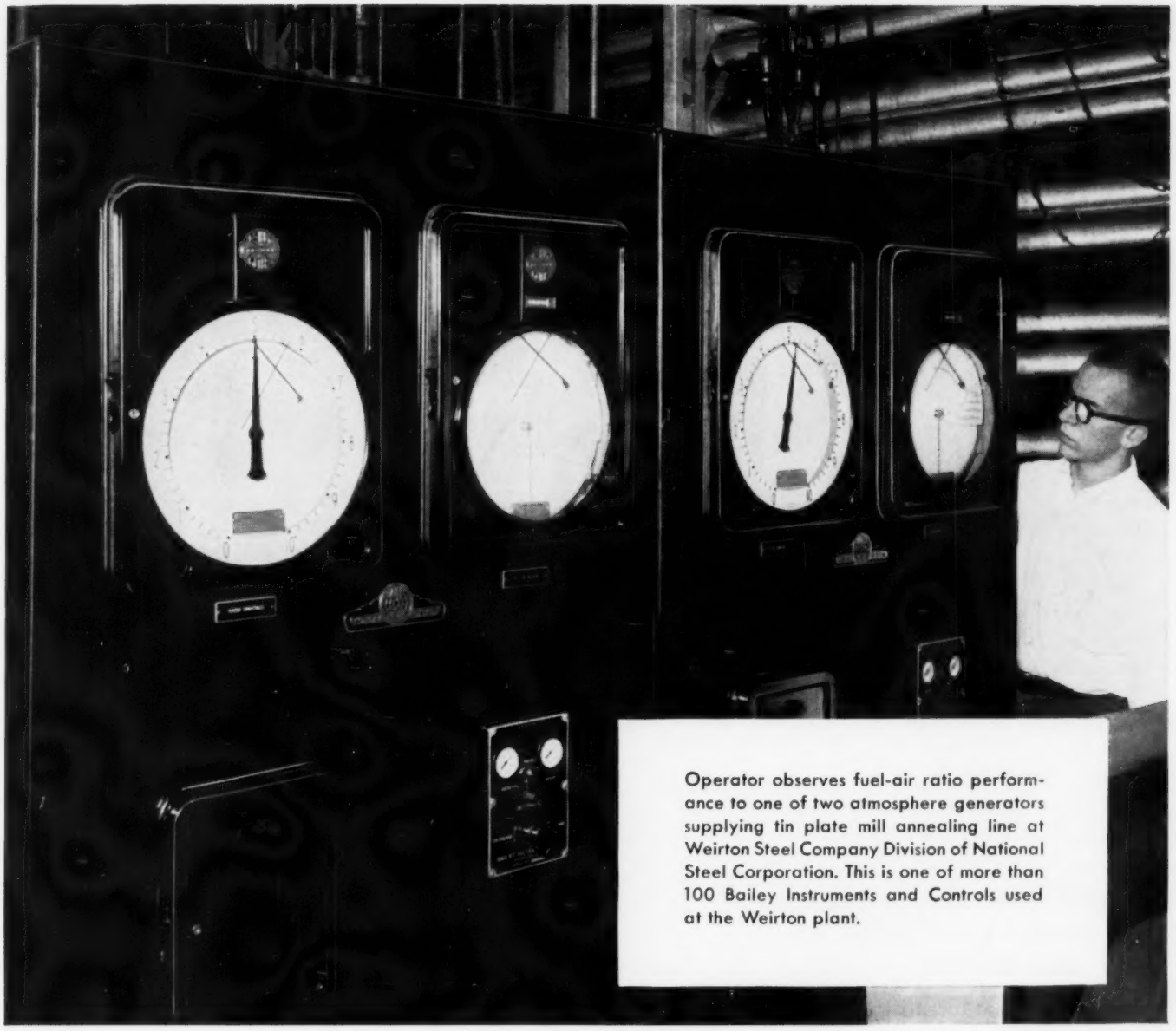
hot strip rolling on MORGOIL BEARINGS

MORGOILS were first installed in 1947 on only four stands of the hot strip mill at Weirton Steel Company, a Division of National Steel Corporation. Other backup roll bearings have been discarded and all eleven stands of the rebuilt mill are now rolling high quality strip on MORGOILS.

MORGAN CONSTRUCTION CO., WORCESTER, MASSACHUSETTS

ROLLING MILLS • MORGOIL BEARINGS • GAS PRODUCERS
WIRE MILLS • EJECTORS • REGENERATIVE FURNACE CONTROL

MB 35



Operator observes fuel-air ratio performance to one of two atmosphere generators supplying tin plate mill annealing line at Weirton Steel Company Division of National Steel Corporation. This is one of more than 100 Bailey Instruments and Controls used at the Weirton plant.

Bailey Atmosphere Generator Control automatically regulates total combustibles for tin plate annealing

Bailey's Atmosphere Generator Control is a completely packaged automatic control system which measures *total combustibles* in annealing.

Manual settings are made only during start-up or shut-down. Fuel-air ratio to generators is adjusted by the control system to maintain constant total combustibles despite variation in fuel quality. Response to atmosphere changes is fast, and total combustibles are accurately measured, since the Bailey Analyzer is not subject to errors due to variability of other atmosphere constituents. The Analyzer is sensitive to changes of less than $\pm 0.02\%$ total combustibles.

The performance of this instrument is assurance of final product quality. See your Bailey Engineer, or write the Iron and Steel Division for more information.

S112-1

IRON AND STEEL DIVISION

BAILEY METER COMPANY

1047 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

BAILEY METERS

DAILY GRIND ALWAYS UNIFORM

with Pennsylvania Reversible Hammermills

Regardless of condition of coal or amount of hammer wear—Pennsylvania Hammermills are noted for producing a highly uniform product day after day.

Basic design and simple adjustments available to the operator on the spot make this possible.

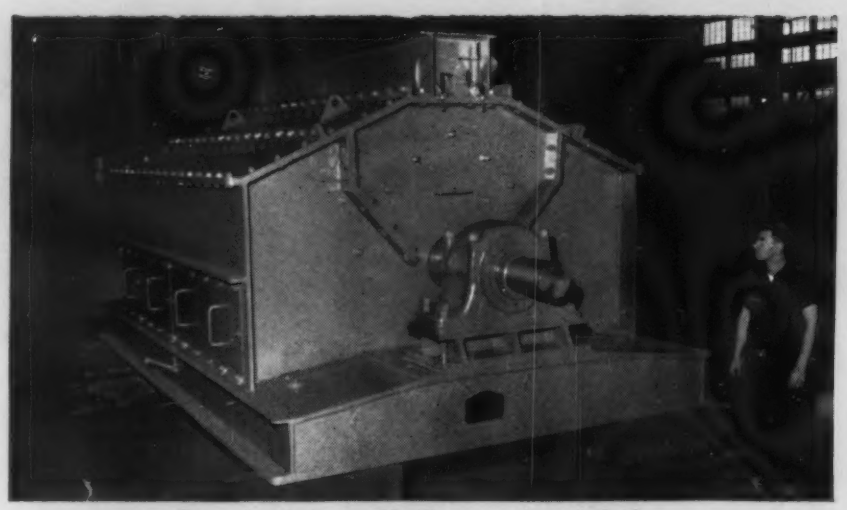
Pin point adjustments of cage-hammer clearance (by ratchet wrench and worm gear assembly) compensate for hammer wear or coal condition.

Crushing action keeps fines to minimum. Free air impact crushing in upper zone prepares coal so there is little dredging of hammers through oversize in cage-bar zone. Results—uniform grinds day after day.

DOUBLE CRUSHING AREA: DOUBLE CAGE, BLOCK AND HAMMER LIFE

No other crushers give you so much more for your money. Pennsylvania Reversible Hammermills give double the crushing area—double the life of cage bars, breaker blocks and hammers. A flick of the switch; rotor is reversed and you are using a duplicate mill.

What's more, hammers need never be hand turned, and wear is kept uniform.



● Pennsylvania Reversible Hammermill, typical of type used in by-product coke plants, ready for shipment.

With adjustable cage assemblies, hammers can be worn much further while keeping grind uniform—with no falling off of tonnage.

FREE BULLETIN

Bulletin 1040, giving a full description of the design, construction features, operation and maintenance of Pennsylvania Reversible Hammermills, can prove profitable reading for you. Write for a copy today.

PENNSYLVANIA CRUSHER DIVISION
BATH IRON WORKS CORPORATION
WEST CHESTER, PENNA.

DOUBLE DIVIDEND!

Pennsylvania Bradford Breaker cleans coal as it crushes

Famous Pennsylvania Bradford Breakers not only crush and size run-of-mine coal—they automatically remove and discharge tramp iron and other refuse. This is just one of many features giving Pennsylvania world leadership for this type of crusher. Over 60 million tons of coal annually are prepared by Pennsylvania Bradfords in coke plants everywhere.

For complete information, write and ask for Bulletin 3009.

★ ★ ★

Over 50 years concentrated experience in all types of material reduction makes Pennsylvania your best source of crushers and engineering advice and service. Call on Pennsylvania with your next crushing problem. Representatives from coast-to-coast.

PENNSYLVANIA
BATH-BUILT
CRUSHERS

Dial LW* for the Last Word in Open Coil Annealing!

The Last Word in annealing is the fabulous Open Coil System that provides steel producers with the greatest flexibility of any annealing system yet developed.

Lee Wilson's Open Coil System permits annealing at "continuous speeds" in variable widths and gauges. Because the furnace operates on the rotary principle it processes each coil individually. For the same reason it requires a very minimum of floor area.

Speed, flexibility, uniformity of anneal and compactness make the Open Coil System the most advanced method of annealing available today. If you are not already familiar with the Open Coil System why not dial Lee Wilson and have a sales engineer contact you at your convenience.

Lee Wilson ENGINEERING COMPANY, INC.

20005 LAKE ROAD • CLEVELAND 16, OHIO

HIGH PRODUCTION ANNEALING SYSTEMS

MAKE THE BEST METALS BETTER

* ORIGINATORS AND LEADING PRODUCERS OF OPEN COIL AND SINGLE STACK FURNACES

KENTANIUM*

ROD MILL ROLLER GUIDES

increase service life 20 to 1

•

reduce maintenance costs 82%

•

improve wire and rod quality

Kentanium roller entrance guides rotate at speeds up to 4500 rpm, as hot wire roc is fed into finishing stand of 9-inch wire mill that handles up to ¼-inch wire or rod

A large metals producing company switched from hardened steel roller guides and bearings to Kentanium, a titanium carbide alloy, for roller guides; and Kennametal,* a tungsten carbide alloy, for bearings. And by making the change, they effected a cost saving of approximately $1 per operating hour, with an expected annual saving of $3600. Here are some reasons . . . obtained from actual performance:

1. At the end of the first 460 hours of mill operation with the new roller guides and conical bearings, only two failures occurred—a center nib broken by excessive overload; and a worn roll caused by the broken center. During a run of the same length, more than 100 sets—over 800 steel roller guides and needle bearings—would have been scrapped.
2. Based on 3600 hours operation per year, maintenance with steel roller guides would have cost $4440. Kentanium roller guides will cut cost to about $800.
3. Average life of Kentanium roller guides with unlubricated conical bearings is 20 times longer than hardened steel roller guides with lubricated needle bearings. This increased roller life, up from 4 hours to 80 hours, reduced downtime and thereby increased productive mill operating time.
4. Kentanium roller guides have improved the quality of wire and rod by practically eliminating scratches.

This is typical of many profitable applications of Kentanium compositions. Perhaps you have a problem that requires a material of great strength at high temperatures, high resistance to wear, and high resistance to oxidation. For detailed information call your nearest Kennametal office or write for booklets "Characteristics of Kennametal"—B111A and "Kentanium"—B444A. KENNAMETAL INC., Dept. IS, Latrobe, Pennsylvania.

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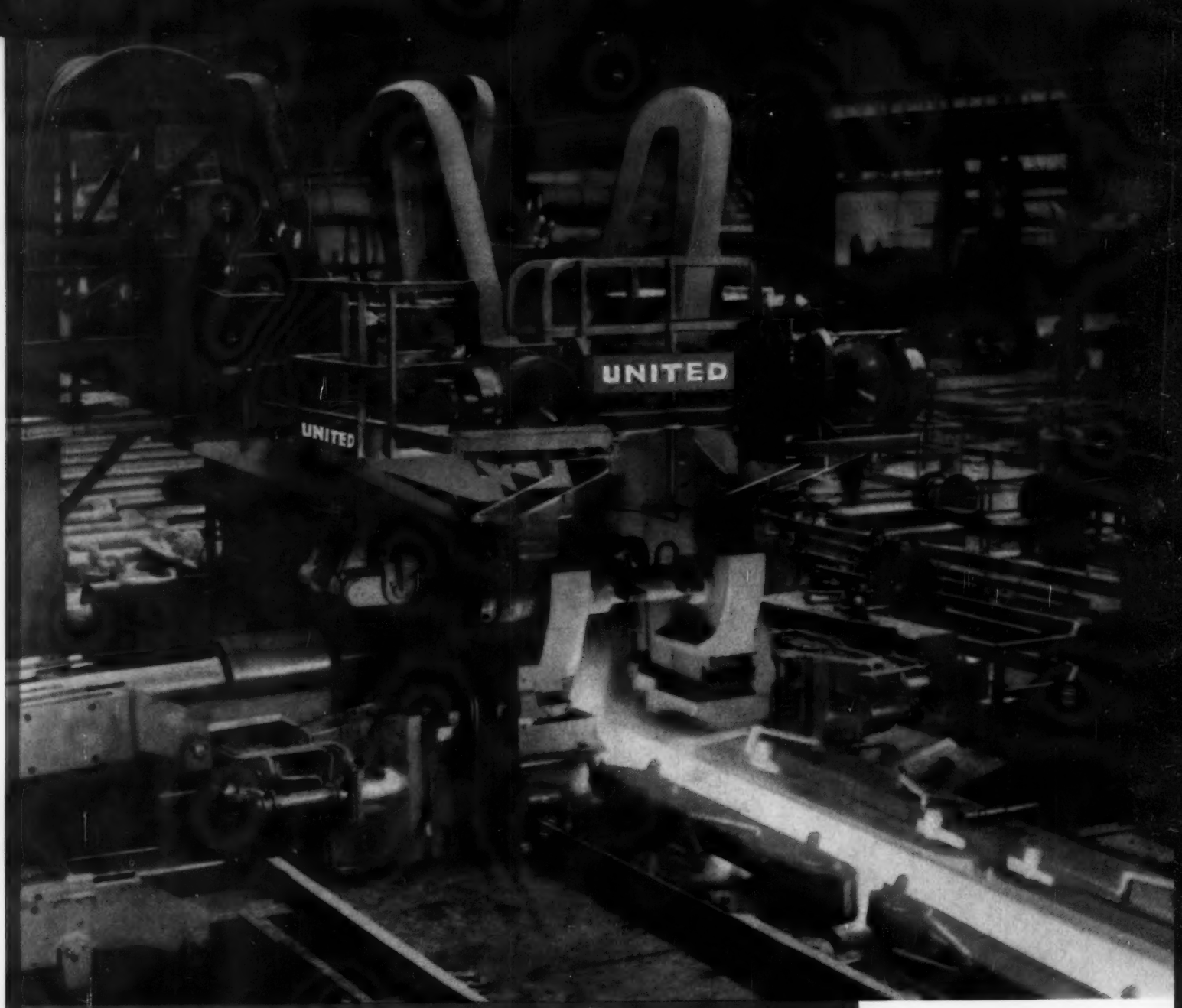

UNITED

WIDE FLANGE BEAM MILL

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PITTSBURGH, PA.

Plants at Pittsburgh, Vandergrift, Youngstown, Canton, Wilmington

SUBSIDIARIES: Adamson United Company, Akron, Ohio; Stedman Foundry and Machine Co., Inc., Aurora, Indiana

Designers and Builders of Ferrous and Nonferrous Rolling Mills, Mill Rolls, Auxiliary Mill and Processing Equipment, Presses and other heavy machinery. Manufacturers of Iron, Nodular Iron and Steel Castings and Weldments.

UNITED ENGINEERING AND FOUNDRY COMPANY

Cleveland Cranes
FOR
STEEL MILL SERVICE
CLEVELAND CRANES
MODERN ALL-WELDED STEEL MILL CRANES
5031 E.289th ST.
WICKLIFFE,
OHIO

Crops and Shorts

△ The 1960 Spring Conference was another successful meeting in this series sponsored by the Rolling Mill Committee of AISE. Registration totaled 923, which has been exceeded only by the 1954 conference in Philadelphia and the 1956 conference in Baltimore. At the dinner, approximately 400 men heard Harleston R. Wood, president of Alan Wood Steel Co., tell engineers that they must consider the human and economic factors attending the project on which they are working. Mr. Wood's talk appears on page 144 of this issue. On the final day of the meeting, 261 men participated in a fine inspection trip to the Bethlehem Plant of Bethlehem Steel Co.

△ The United Nations Economic Commission for Europe has published a book, "Long-term Trends and Problems of the European Steel Industry," which estimates steel production in 1972–1975 as follows:

	Metric tons
Eastern Europe	38,200,000
U.S.S.R.	117,000,000
Western Europe	161,200,000
North America	159,500,000
Latin America	18,700,000
Africa	7,500,000
Far East (excluding China)	65,000,000
China & North Korea	52,000,000
Middle East	2,300,000
Oceania	9,300,000
Total	630,700,000

△ It is estimated that the steel industry of the world will spend almost $5,000,000,000 this year for expansion and modernization. About one-third of this is scheduled to be spent by U. S. companies. Russia will spend more than $1,000,000,000; Japan $500,000,000; the United Kingdom and the European Coal and Steel Community, $600,000,000. Large expenditures will be made in South America, India, Canada, Mexico, Turkey, Spain, Portugal, Africa and many other countries.

△ A recent survey shows the median salary of college teachers to be about $6800. Results showed 300 teaching positions in excess of $18,000 and 1000 positions paying more than $15,000, but also 13,000 full-time teachers receiving less than $5000 for the nine-month academic year.

△ An experienced friend of ours says the old fashioned girl used to take two drinks and go out like a light. The modern girl takes two drinks and out go the lights.

△ Companies representing 93.6 per cent of the ingot production of the United States reported to the American Iron and Steel Institute as follows for 1959:

Ingot Production, net tons	87,419,602
Shipments of finished steel products, net tons	66,485,380
Number of employees, hourly	554,483
Number of employees, salaried	167,116
Man-hours worked, hourly	949,300,183
Man-hours worked, salaried	340,380,884
Total payroll	$4,636,320,669
Total income	$14,232,411,074
Employment Costs	$5,137,657,866
Materials, supplies & services	$6,442,018,712
Total Costs	$13,402,720,528
Net income	$829,690,546
Total assets	$15,714,715,854
Number of stockholders	1,064,892

△ U. S. steelmakers' outlook on steel imports is less gloomy than it was last year. Many users are switching back to domestic steel, which offers better delivery, wider variety and size range, better service on claims, etc. Estimates for 1960 imports average about 3,000,000 tons, some 30 per cent less than 1959's 4,391,971 tons but still considerably above the 1,702,819 tons of 1958.

△ C. M. White, board chairman of Republic Steel Corporation, listed some items which will help American steelmakers to recapture some of their lost markets: "Continuing our fight to slow down the rate of increase in our employment costs.

"Elimination of wasteful work practices through joint company-union effort.

"Greater productivity and efficiency from our plants and our work force."

△ A. S. Glossbrenner, president of The Youngstown Sheet and Tube Co., told the Washington Society of Investment Analysts that the American steel industry would likely produce between 115,000,000 and 120,000,000 net tons of steel ingots in 1960.

△ Motor vehicle accidents killed 37,600 and injured 2,870,000 persons on U. S. highways in 1959. Driver errors caused 85 per cent of these accidents, with speed the leading sin. Although making up less than 14 per cent of the driving population, drivers under age 25 were involved in nearly 29 per cent of all fatal accidents.

△ According to the American Iron and Steel Institute, steel production set a quarterly record during the first three months of 1960 with the pouring of 34,739,210 net tons of steel.

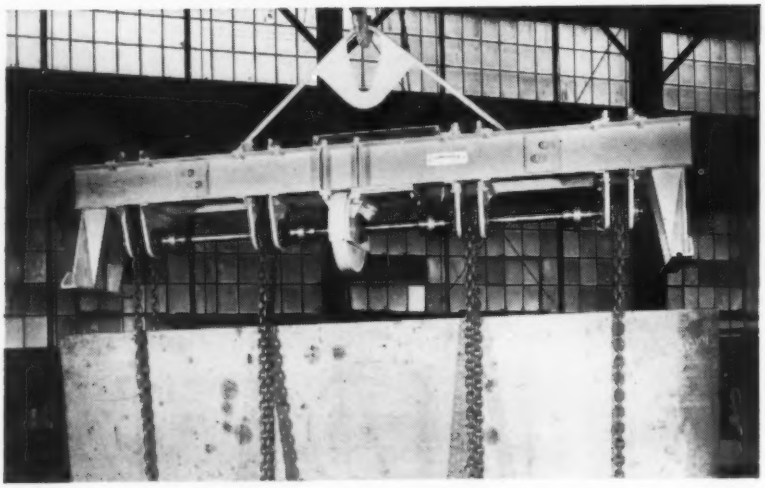
△ An item in the William Feather Magazine discusses vodka, observing; "It can be combined with almost anything: tomato juice, ginger beer, the cola drinks, orange juice, grapefruit juice, chicken broth, etc. We have a friend who pours it over oatmeal instead of cream."

What's the matter with putting it in buttermilk?

△ Steel company earnings for the first quarter of 1960 show general improvement over 1959's first quarter, averaging about 9.8 per cent better.

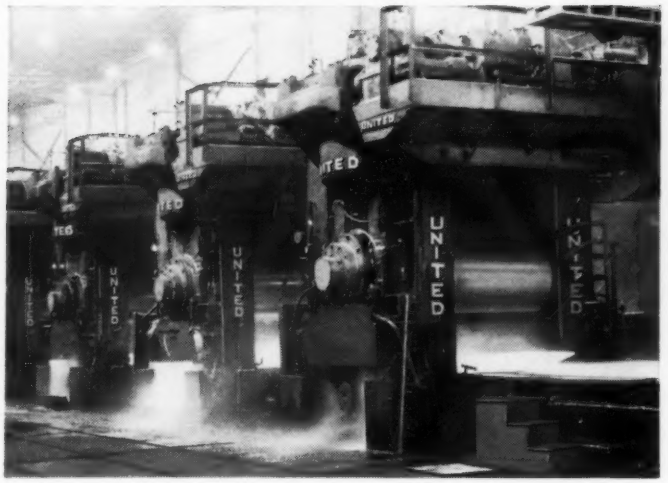
△ When this appears in print, your editor will be touring some of the steel plants of Britain and Europe. England, Wales, Netherlands, Belgium, France, Luxembourg and Germany are included in the itinerary. It will be interesting to see how the other half works.

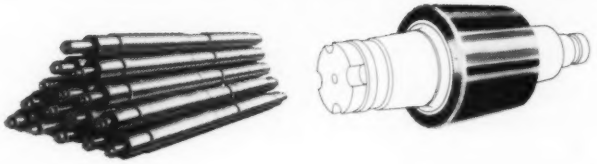
Heppenstall handles it...



Handles it: "If it hangs from a crane, Heppenstall can handle it." Stock tongs are ready for immediate delivery; custom designs are made for special requirements.

rolls it...





Rolls it: Heppenstall and Midvale-Heppenstall Rolls and Sleeves are made from highest quality alloy steel, thoroughly worked under modern hydraulic presses to obtain maximum density and grain refinement.

cuts it...

Cuts it: A knife is only as good as the steel that's in it. Heppenstall has the variety of electric steel grades to meet the growing need for knife durability at various shearing speeds.

HEPPENSTALL COMPANY • PITTSBURGH 1, PENNSYLVANIA
Plants: Pittsburgh, Pa. • Bridgeport, Conn. • New Brighton, Pa.

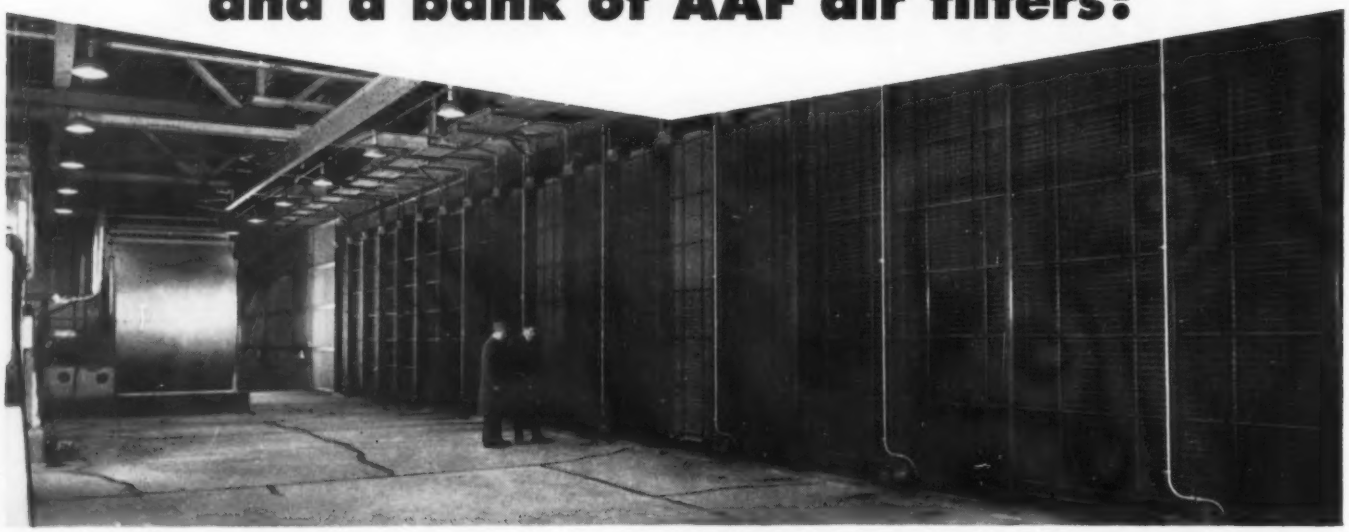
MIDVALE-HEPPENSTALL COMPANY • NICETOWN, PHILADELPHIA 40, PA.

Die Blocks • Forgings • Back-Up Roll Sleeves Rings • Industrial Knives • Materials Handling Equipment • Pressure Vessels • Hardened and Ground Steel Rolls • Vacuum and Consumable Electrode Melted Steels

9236

What's behind this spotless motor room?

Sound investment-protection planning, and a bank of AAF air filters!



AAF ROLL-O-MATIC filters protect vital equipment for Weirton Steel Company

Weirton Steel didn't give dust a chance to hamper the functioning of their massive motor room equipment. From the complete AAF filter line, they selected the automatic, renewable-media Roll-O-Matic . . . installed 30 sections totalling 887,000 cfm.

Their reasons: the same reasons that have led to the installation of Roll-O-Matics at 2,100 locations since 1954 — (1) completely automatic operation, (2) maintenance as simple as changing the film in a camera, (3) high cleaning efficiency, and (4) large dust-holding capacity.

For more reasons, call your nearest AAF representative, or write direct for Roll-O-Matic Bulletin 248C. Address Mr. Robert Moore, American Air Filter Company, Inc., 302 Central Avenue, Louisville, Kentucky.

AAF American Air Filter

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Triple-fired slab furnace—Detrick monolithic sidewall construction

No other organization has designed so many refractory constructions, served so many important users of industrial heat, maintains so large an engineering department, or has contributed so much to heat enclosure engineering (a typical example is the flat suspended arch which was originated and developed by Detrick).

In monolithic as in every other type of refractory construction, Detrick's experience, performance record and integrity are a triple guarantee of design and application based on an *impartial* engineering analysis of the conditions, and an *unbiased* selection of the methods and materials best qualified to meet them . . . triple assurance of long, maintenance-free service . . . triple reason to get in touch with Detrick when considering monolithic or any other type of refractory construction.

May we send you a copy of our Bulletin D39 on Engineered Monolithic Constructions?

DETRICK Heat ENCLOSURES

MONOLITHIC DEPARTMENT

M. H. DETRICK COMPANY

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The Pennsylvania Tidewater Dock Company reports . . .

"1959 ore handling tonnage reached record all-time high at Pennsylvania Railroad's Greenwich Ore Pier, Philadelphia"

Mr. George R. Johnson, president of the Pennsylvania Tidewater Dock Company, operators of the pier, says: "Last year we achieved: (1) a new annual record, just short of 7 million tons; (2) a new single month's record of 1,150,587 tons; and (3) a single day's record of 69,383 tons. An important factor in establishing these records has been the absolute minimum of downtime required for maintenance of our Dravo units."

Results like these are not unusual with Dravo heavy materials handling equipment. We would like to discuss your requirements with you. Write to Dravo Corporation, Pittsburgh 25, Pa.; or call SPalding 1-1200.

One of two Dravo 1800-ton-per-hour unloaders in operation at Greenwich Ore Pier.

DRAVO
CORPORATION

To Meet Customer Demands

New Side Trimming Line Installed In Tin Mill Will Improve Production Of Tinplate In Coils

Installation Called Most Modern Of Type In Industry

A new side trimming line to facilitate the production of tinplate in coils in Weirton Steel's Tin Mill Department was placed in operation recently.

W. H. Wright, Vice President and Chief Engineer, said the new installation, rated among the most modern pieces of equipment in the steel industry, was installed because of the increasing demand from customers for tinplate in coil form. The company will also continue to ship tinplate in the conventional cut sheets.

The new side trimming line, which began operating last month, and a second line, installed on an emergency basis, are used to trim the sides of the sheet steel before it is plated with tin, so it can be wound into coils and be ready for shipment as it comes off the tinning lines.

Mr. Wright explained that Weirton Steel's No. 4 and No. 5 tinplating lines have been equipped with edge control reels which insure that each coil is wrapped with a straight edge. This is necessary to prevent damage to the edges in bundling and shipping and also because straight edges are required when the coils are processed further by Weirton Steel customers.

Mr. Wright also reported the installation of a new bundling line, which began operating about three months before the new side trimmer. The bundling line utilizes machinery to wrap coils in heavy paper and fasten them with steel straps. Formerly, this was a hand operation.

The side trimming operation takes place after the steel has been tempered to customer specification by the skin mills and before it is plated with tin. This process eliminates the waste which formerly resulted when the side trimming was done on the cutting lines, after the tinplating process.

The No. 2 side trimming line has a maximum speed of 4,000 feet per minute while the No. 1 line operates at a speed of 1,200 feet per minute. The No. 2 line is able to handle 30-ton coils 85 inches in diameter and 45 inches wide. The line also is equipped with a mash welder, a relatively new operation which provides a smoother weld that does not damage other sections of the coil as it is wound.

All of the new facilities were designed by the Weirton Steel Engineering Department and installed by the company's Construction Department.

Reprinted from Employees Bulletin, Weirton Steel Company, February, 1960

Due to increasing demands from customers for tinplate in coil form, a new side trimming line was installed recently in the Tin Mill. The new trimming line, designed by Weirton Steel's Engineering Department and installed by the Construction Department, [illegible] of sheet steel before it is plated with tin.

Once again—

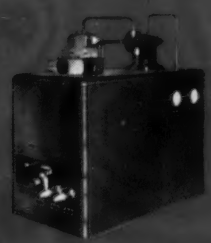
proof that GPE Controls is the Steel Industry's "Partner in Progress"

The tin mill side trimming line at Weirton Steel Company, Division of National Steel Corp., was furnished by Wean Engineering Co., and equipped with the industry's most modern edge guide equipment—designed and built by GPE Controls, Inc.

Only GPE Controls offers steel mill edge guides with . . .

- ★ **Non-clogging sensing nozzles with lowest air consumption.**
- ★ **Unlimited force output with cylinder pressures to 2000 p.s.i., flows to 140 g.p.m and higher.**
- ★ **Variable-gain booster for simple screwdriver job-site matching of control system to speed, coil weight, etc.**

Write for NEW Bulletin EG84, which tells all about GPE Controls web guiding systems—and be sure that GPE Controls are specified and furnished on your next strip and tin mill installation.



GPE Controls Model 300 Edge Control, as furnished to Weirton Steel Company.

GPE Controls, Inc.
240 East Ontario Street
Chicago 11, Illinois

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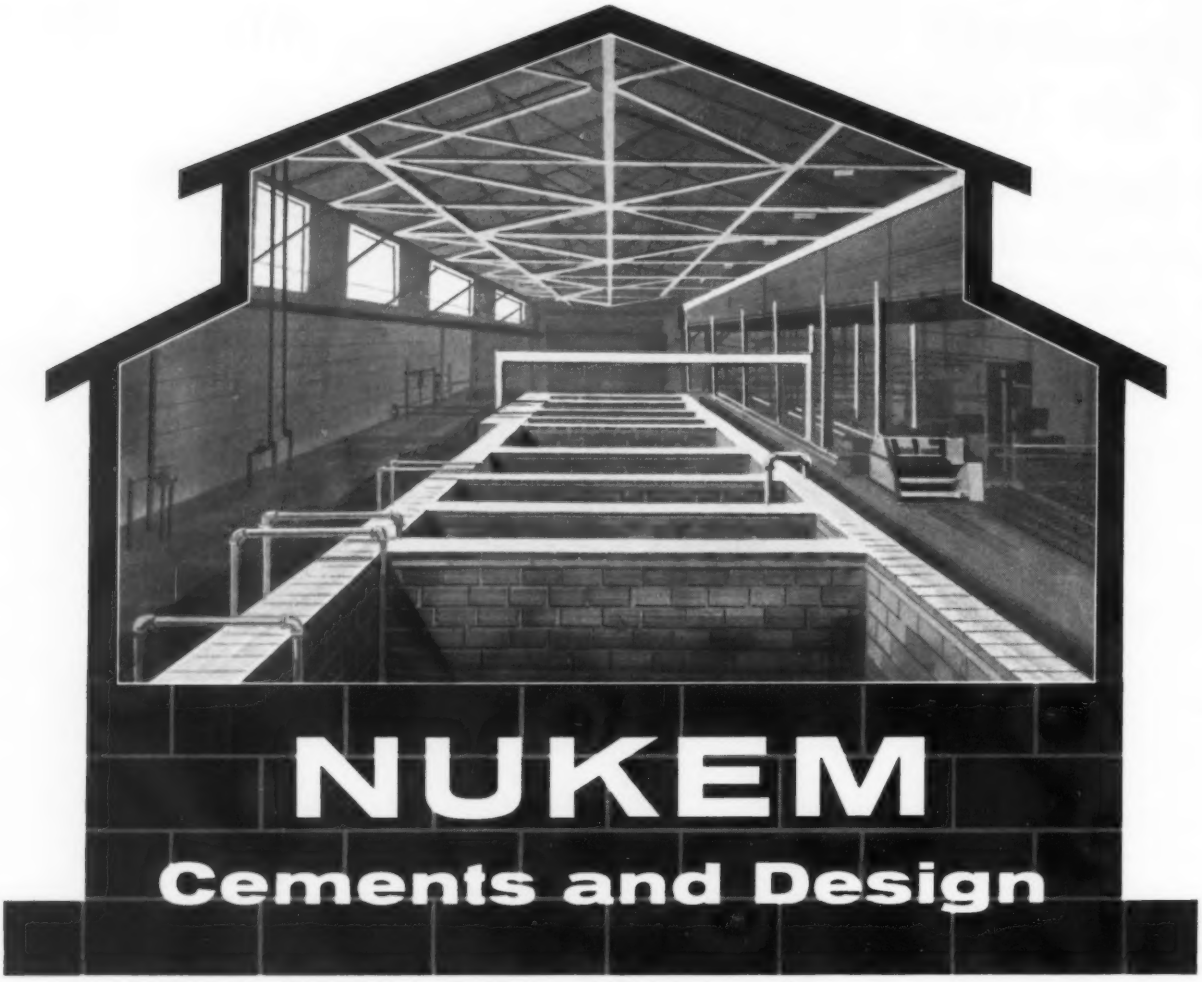

...add years of service to your tanks and foundations

Sulphuric, hydrochloric, nitric or hydrofluoric acids... nickel salts or caustics... no matter what corrosive solutions your processes require, there is a Nukem cement designed for your service.

For over 35 years, Nukem has specialized in the manufacture of a complete line of acid and/or alkali proof cements and linings—each bearing the hallmark of "top quality." Over this same period—employing these products—the name NUKEM has been associated with successful, reliable, corrosion proof construction of Pickling Tanks, Neutralizing Systems, Foundations, Manholes, Trenches and Sewers.

Permanent, satisfactory results depend upon accurate analysis of the problem and selection of the exact material to meet every requirement. Proper design is essential and Nukem engineering "know-how" is at your service. For lasting and economical corrosion resistance, be sure you specify NUKEM.

NUKEM CEMENTS

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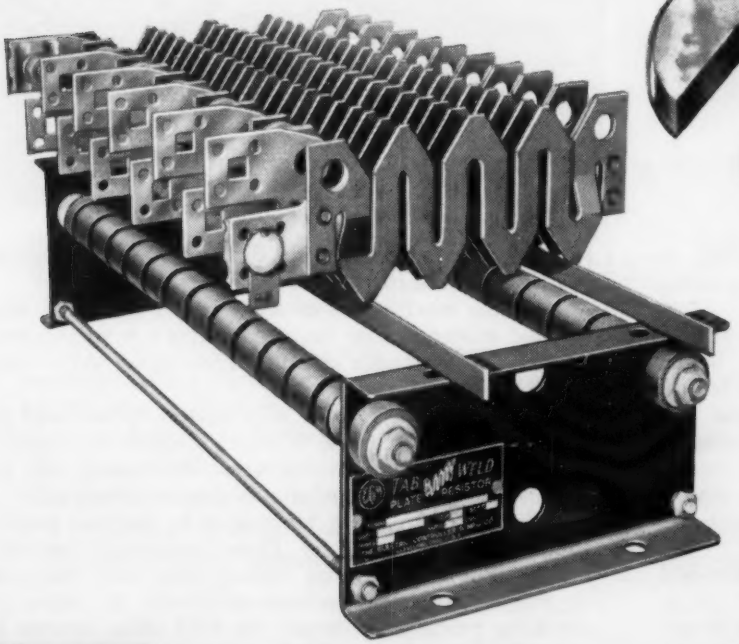
N 102

HANDS OFF!

EC&M TAB-WELD RESISTORS REQUIRE *MINIMUM* MAINTENANCE

Only EC&M TAB-WELD PLATE RESISTORS are both bolted and welded for constant current path. Unlike other resistors, they do not require periodic tightening of clamping nuts to compensate for loss of pressure caused by alternate heating and cooling. Grids are offset and mating ends are spot welded. Tap-plates are also welded into place at close intervals along the grid assembly.

This exclusive EC&M construction offers 4 big advantages on heavy duty motor applications: (1) stabilized ohmic value (2) no burning at grid-eyes or at tap-plates (3) easy tap-shifting for best motor performance and (4) long life with virtually no maintenance!



FEATURES THAT REALLY COUNT!

- Nonbreakable
- Corrosion-resistant alloy steel
- Negligible resistance change between cold and maximum working temperatures
- Offset resistor ends spot-welded
- No burning at grid-eyes
- No burning at taps
- Small adjustments in resistance value easily made
- Insulating spacers remain dimensionally stable
- No periodic tightening of clamping nuts
- All standard sections same size
- Double insulation to ground
- Fast connection to any tap-plate

***Write** for illustrated Bulletin 6715*
Complete data on EC&M TAB-WELD RESISTORS

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EC&M DIVISION • CLEVELAND 28, OHIO
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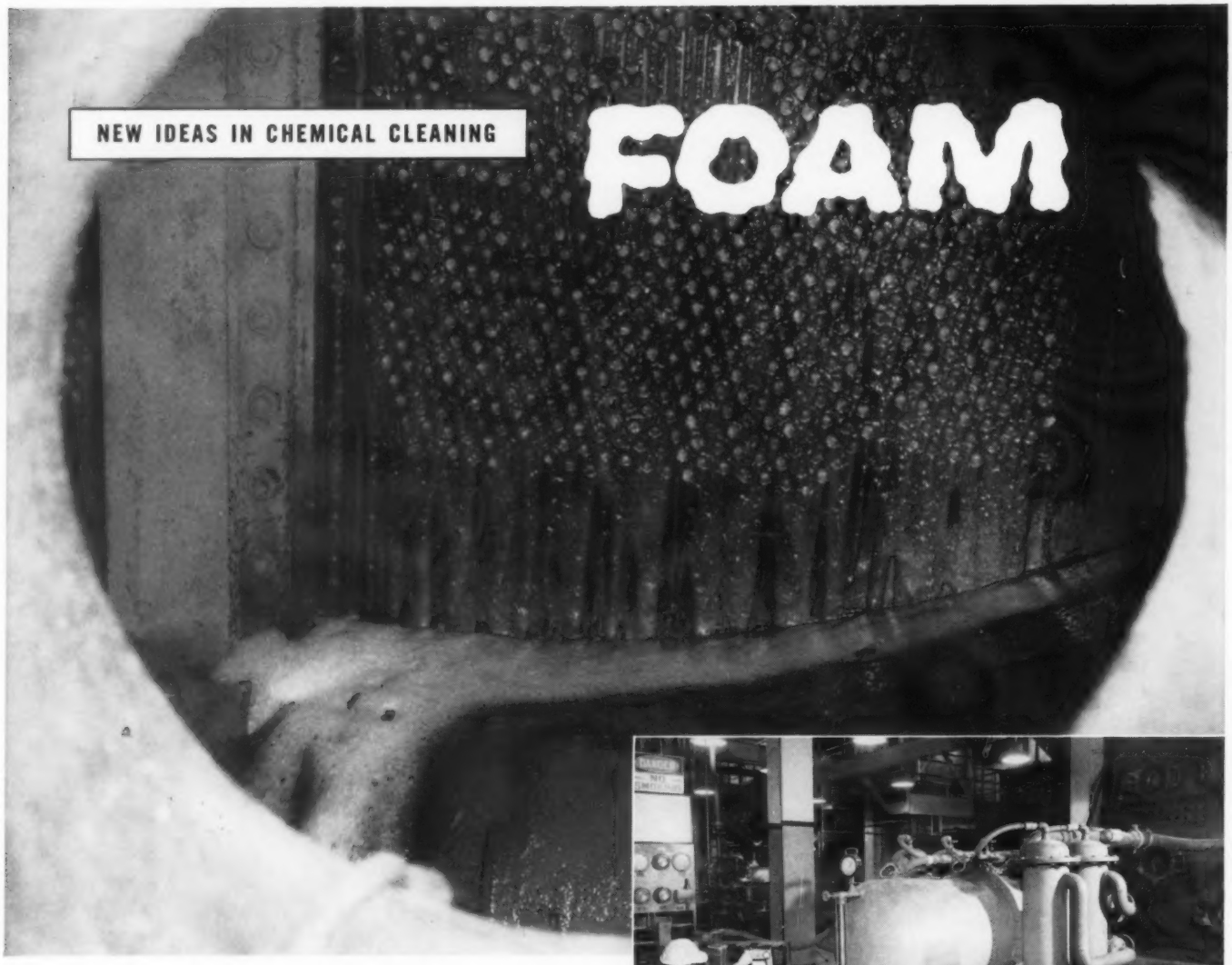


Above: This view through a condenser inspection port shows foamed acid in action. Right: A foam generator being used to clean a large condenser.

Dow Industrial Service Uses Foam For Better Cleaning, Lower Cost

A newly-developed method of chemical cleaning is helping plant operators reduce the cost of cleaning large-volume vessels.

The new method uses a foaming agent and a special foam generator to expand inhibited acids, water or alkaline solutions to many times their liquid volumes. Foam-to-liquid ratios up to 300-to-one can be attained. For most applications, however, acid is expanded 20 times.

Chemical costs of cleaning large volume vessels with foam instead of liquid are reduced because far less solvent is required.

Reduced solvent requirements mean that disposal or neutralization is simplified.

The light weight of foam makes possible the chemical cleaning of structures where weight is critical.

Foam cleans faster than liquids because solvents can be used at higher concentrations. This helps to reduce both cleaning and outage time.

Certain mechanical benefits result from the use of foamed solvents. The foam provides a scouring action not given by liquids and it carries sloughed materials readily.

Also, foamed solvent fills vessels, pipes and even bent piping as a plug. This eliminates the need for vent connections and reduces the hazard of gases because they are swept out as they are formed.

The foam cleaning technique is just one of many recent developments by Dow Industrial Service to make chemical cleaning faster, safer and less costly.

For engineered recommendations to solve your cleaning problems, contact the field office nearest you, or write Dow Industrial Service, 20575 Center Ridge Road, Cleveland 16, Ohio.

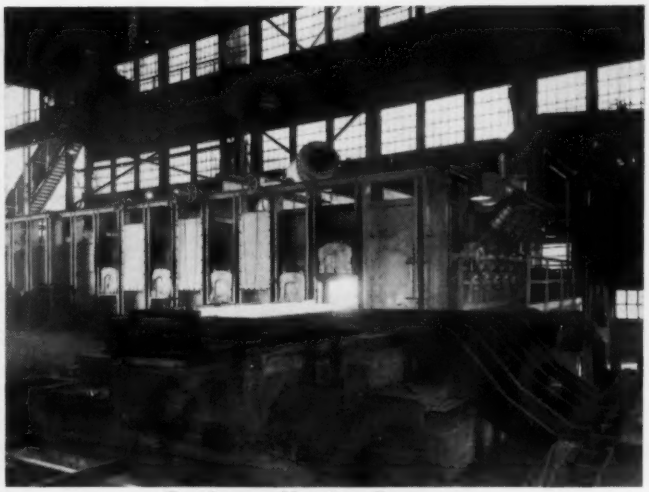
Chemical Cleaning Services for all industry

DOW INDUSTRIAL SERVICE

DIVISION OF THE DOW CHEMICAL COMPANY

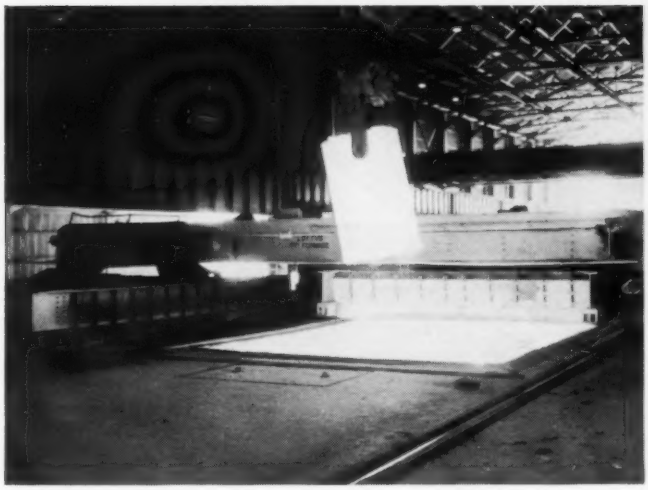
DOW

Open Hearth Furnaces—Photo Courtesy
Jones & Laughlin Steel Corp.



Continuous Heating Furnaces—
Photo Courtesy Crucible Steel Co.

Soaking Pit—Photo Courtesy
United States Steel Corp.



Heat Treating Furnace—
Photo Courtesy Taylor Forge & Pipe Works

Increase Production . . . Lower Production Costs with

LOFTUS Industrial FURNACES

For years Loftus Industrial Furnaces have been providing dependable, economical service to the steel industry. Their long life and efficient performance have been proved by time. The fact that they materially contribute to lower-cost operation and increased production is a matter of record.

Whatever your heating or heat-treating requirements, it will pay you to take advantage of Loftus' long experience in furnace design and construction. Many of the world's leading companies have—and to their utmost satisfaction, as proved by the high percentage of repeat orders we get.

We would welcome an opportunity to quote on your requirements.

From first heat to heat treat, look to **LOFTUS**

Engineering Corporation

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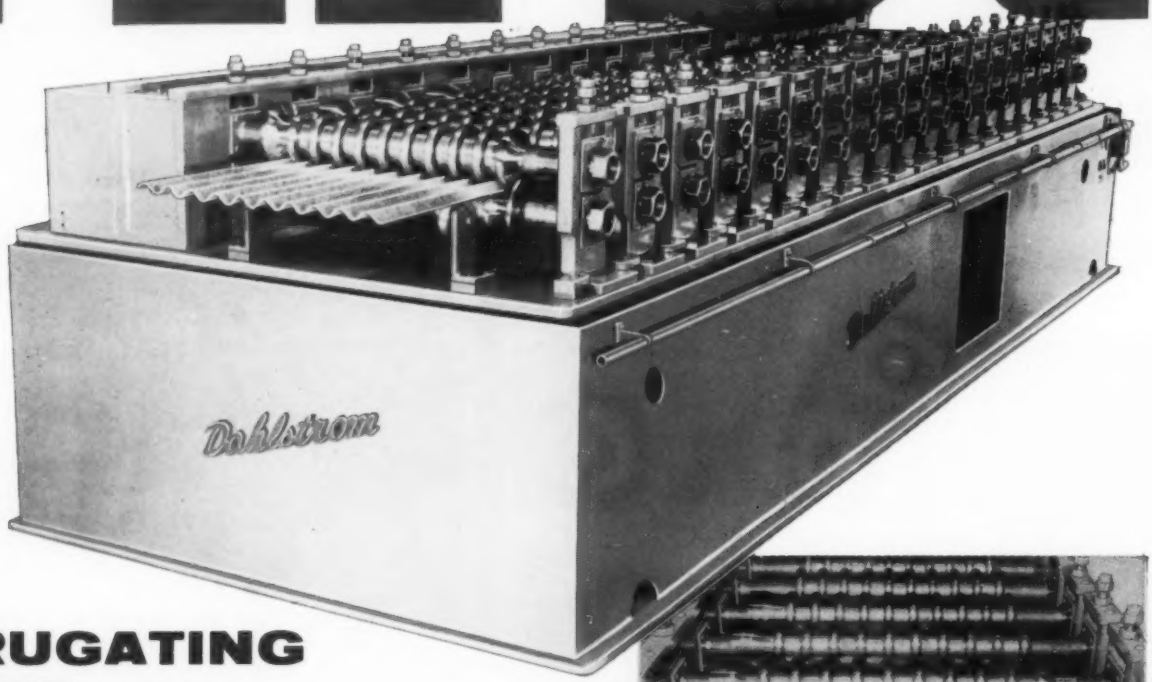
56•23•3

another *Dahlstrom* First



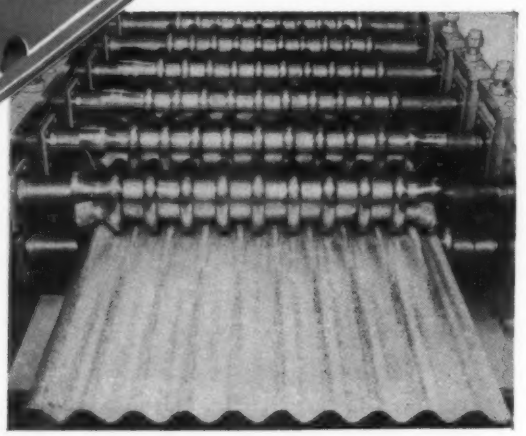
CORRUGATING SHEETS with a *Dahlstrom* ROLL FORMING MACHINE

- NO MAXIMUM LENGTH RESTRICTIONS
- EXCELLENT CONTROL OF COVERAGE AND DEPTH
- PRODUCES SHEETS OF THE HIGHEST QUALITY
- For corrugating 20 through 28 gauge galvanized steel, aluminized steel, plain and embossed aluminum.
- Requires only vertical adjustment for gauge range. Roller die tooling available for ½" or ⅞" depth.
- Other gauge ranges also available—send complete detailed specifications for quotation.

featuring:

All welded construction

Roll shafts mounted on anti-friction bearings



This setup is available as an individual unit for feeding sheets as illustrated; with a complete Dahlstrom Decoiling and Shearing Line conveying cut lengths into forming machine; or as a complete roll-forming line utilizing coil stock and cutting to length after forming.

Complete line of Cold Roll Forming Equipment available for other shapes. Capacities up to ¼" material thickness.

Dahlstrom MACHINE WORKS
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Roll forming machines, flying cut-off presses, coil reels, coil lifts, roll straighteners, press feed lines, decoiling and shearing lines.

4226 W. Belmont Ave., Chicago 41, Ill. — Phone: SPring 7-3670

patent reviews

By MELVIN NORD, Patent Attorney, Detroit, Mich.

Copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C. at 25 cents . . . patents reviewed cover period December 1, 1959 to December 29, 1959

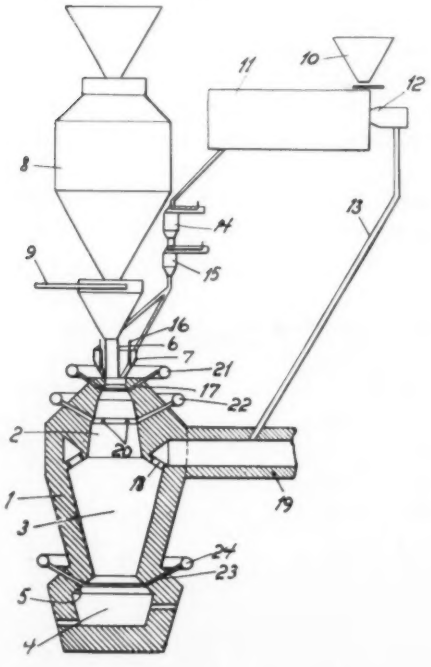
OPERATION OF A GAS GENERATING SHAFT FURNACE AS A BLAST FURNACE OR AS A CUPOLA

△ U. S. 2,919,185, issued Dec. 29, 1959, to Nils R. Wahlberg and assigned to Axel A. Severin, describes a method of operating a gas generating shaft furnace either as a generator, a blast furnace or a cupola.

When the furnace operates as a generator its main function is to generate from carbonaceous fuels a dry generator gas with a high temperature, about 1000 C, a low content of CO_2, and a high content of combustible constituents, about 45 to 50 per cent $CO + H_2$, the fuel transferring all its energy to the gas.

When the furnace operates as a cupola its main function is to enable gasifying fuels to be used instead of coke for the melting and to render possible a continuous operation.

Figure 1



When the furnace operates as a blast furnace its main function in doing so is to use coal instead of coke and more or less finely grained concentrates instead of coarse sinter and/or ore.

As shown in Figure 1, the top portion 2 is provided with one feeding hopper 6 for coal and one feeding hopper 7 for ore concentrates. The coal is stored in a container 8 from which it is dumped into the furnace through a damper 9. The coals enter centrally in the top 2 through the pipe 6.

The concentrates are supplied through a hopper 10 into a drying oven 11 heated by means of gas which is taken off from the furnace through a conduit 13 and burned in a burner 12. The dried concentrates are fed through locks 14 and 15 in the feeding hopper 7 provided with a damper 16, the feeding hopper surrounding the feeding pipe 6 for the fuel so that the concentrates will be fed annularly around the fuel.

Gas off-takes are disposed annularly at that place where the top 2 widens toward the bosh 3. The gas off-takes are interconnected by a gas channel 19.

Intake openings for hot air are arranged in the top of the furnace on two different levels. On the upper level the intakes are shaped like a slot 17 directed obliquely downwards, encircling the whole shaft and being positioned at a point where the top widens rather strongly downwards, immediately below the intake point for fuel and concentrates. On the lower level the intake openings are shaped as a number of tuyeres 20 which also are directed obliquely downwards.

Air intakes are also arranged in the conical ceiling 5 of the hearth 4. The intakes are shaped as a slot 23 directed obliquely downwards encircling the whole crucible.

The hot air is supplied to the various intakes by means of conduits 21, 22 and 24, respectively.

Thus, coal is supplied at the upper section of the furnace, hot air is admitted at the top of the furnace, and gas formed is drawn off at a lower level. The tar constituents of the fuel are distilled off and gasified by the hot air, without the slag constituents of the coal sintering.

The furnace operates on the whole in such a manner that it first burns the tar of the fuel and then the coke thus formed, while an ordinary generator always burns the coke first and distills the tar afterwards.

CONTROLLING THE COMPOSITION OF PIG IRON AND NORMAL SLAG IN A BLAST FURNACE

△ U. S. 2,918,365, issued Dec. 22, 1959, to Kuro Kanamori, et al., and assigned to Yawata Seitetsu K.K., describes a method for controlling the composition of molten pig iron and slag in a blast furnace, by directly feeding a treating agent into the molten pig iron in the bath through the blowing tuyere.

A cylinder containing the desired treating material (e.g., fer-

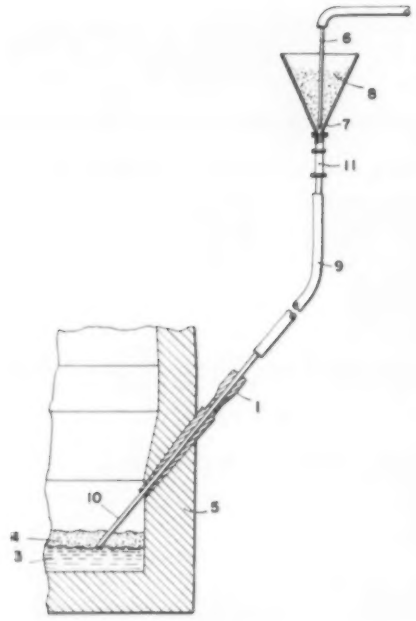


Figure 2

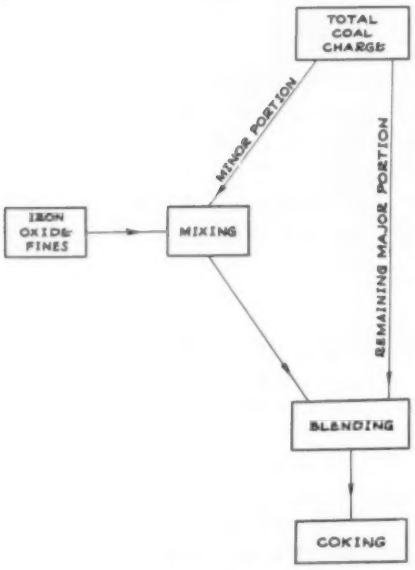
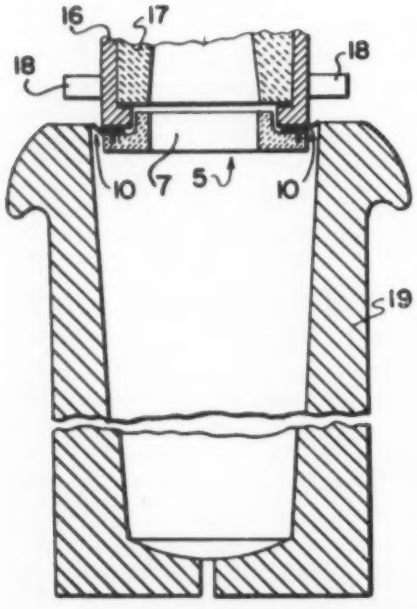


Figure 3

Figure 4



romanganese) may be dropped through the tuyere directly into the molten pig iron. Alternatively, as shown in Figure 2, a flow pipe 10 may be inserted directly into the molten pig iron 3 through the tuyere 1, the upper end of the pipe being connected to the lower opening of a hopper 8 filled with lime powder by a pipe 9 and jointed pipes 11. In hopper 8 is a jet nozzle 6 positioned so that the opening 7 of the nozzle is opposite the lower opening of said hopper 8.

When high pressure air or gas is forced through the nozzle 6, the lime powder in the hopper 8 is sucked into the pipe 11 due to the low pressure induced at the opening 7, so that the lime powder can be effectively fed into the molten pig iron together with the air or gas of high pressure through the pipes 11, 9 and 10.

MANUFACTURE OF IRON-COKE

△ U. S. 2,919,231, issued Dec. 29, 1959, to Ernest E. Donath and assigned to Koppers Co., Inc., describes a process of manufacturing iron-coke, in which intimate mixture of the iron oxide and coal is obtained, resulting in a stronger coke product and one in which a larger amount of the iron oxide is reduced to the metallic state.

The process consists of the steps, shown in Figure 3, of intimately mixing iron oxide fines with a small or minor portion of a total coal charge with which the fines are to be mixed, blending this iron oxide-coal mixture with the remaining or major portion of the total coal charge and coking the blended mixture.

HOT TOP

△ U. S. 2,914,824, issued Dec. 1, 1959, to Ervin A. Marcec, assigned in part to Frank H. Ellenbaum, provides a composite bottom ring and wiper arrangement and a composite hot top liner insert and wiper arrangement.

In Figure 4, there is illustrated the manner in which the composite wiper-ring 5, 10 of this invention would appear in position between an ingot mold 19 and a hot top shown only in part and including its casing 16, refractory lining 17 and supporting trunnions 18.

When a composite liner-wiper insert as shown is employed, the use of a bottom ring is unnecessary as the lower lip portion acts as a shield for the hot top casing 16 in the same manner as would a bottom ring. The liner insert is supported from the hot top by clamps not shown in the same manner as bottom rings are conventionally supported.

SLOTTED HOT TOP

△ U. S. 2,914,825, issued Dec. 1, 1959, to Edgar Marburg and assigned to United States Steel Corp., provides a slotted hot top for use in casting steel ingots, in which the slots serve as an effective barrier to the transfer of heat from the sinkhead through the hot top wall.

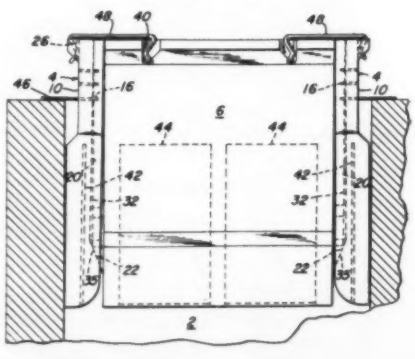
As shown in Figure 5, narrow vertical slots 42 are formed in the side and end slabs 4 of the hot top. As steel is poured into the mold it cannot rise into the narrow slots because of the narrow width of these slots and because the slots are not vented. However, air will be entrapped therein and will be heated to a very high temperature, thus serving as an effective barrier to transverse heat flow from the sinkhead through the hot top wall.

CONTINUOUS DIRECT REDUCTION OF IRON ORE

△ U. S. 2,915,379, issued Dec. 1, 1959, to Jagdish C. Agarwal, assigned to United States Steel Corp., describes a method for handling reducing gas in a continuous direct reduction process for metallic oxides, in which need for an outside energy source to pressurize recycled gas is eliminated or minimized.

As shown in Figure 6, the system includes a power recovery device, such as an expander turbine compressor for using fresh reducing gas inherently at high pressure to pres-

Figure 5



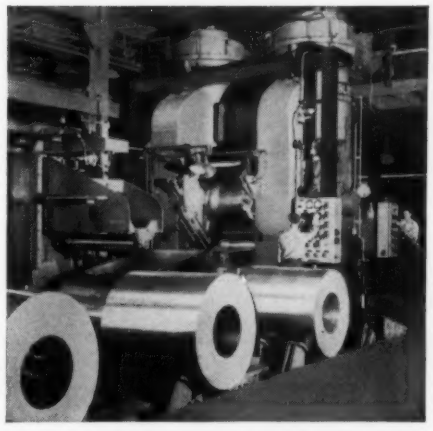
Bliss mills add hardness to Weirton Steel's line of strip

Weirton Steel Co., Division of National Steel Corp., the nation's largest independent producer of tin plate, uses a Bliss mill to achieve exacting temper and quality of its strip prior to plating. It is a four-high, two-high two stand tandem mill recently installed in its Weirton, W. Va., plant.

Through this unit Weirton has rolled a wide variety of steels in gages ranging from .00435 to .0147 inches and at an average maximum speed of 4,500 feet per minute. Well known products such as Weircote and Weirzin zinc coated steel are just two of Weirton's steel products to which this mill contributes.

A second Bliss mill tempers high-carbon, high-phosphorous, deep-drawing and galvanizing steels at the rate of 800 tons a day, while a new Bliss 48-inch slitting line is used to slit galvanized steel in gages from .0135 to .135 inches at speeds of 200 to 1,000 fpm. Both rolling mills are equipped with Amerigear-Bliss spindles.

These three installations provide one more example of the ready acceptance of the name of Bliss in the rolling mill industry—both here and abroad. To learn how Bliss equipment can help increase your rolling capacity, simply write for our new 84-page Rolling Mill Brochure, Catalog 40-B.



Four-high temper mill handles 30,000-lb. coils at speeds up to 3,500 fpm...has rolled 1,000 tons in a single day. Back-up rolls were supplied by Bliss' Mackintosh-Hemphill Division.

BLISS
SINCE 1857

Bliss is more than a name . . . it's a guarantee

E.W. BLISS COMPANY, Rolling Mill Division, Salem, Ohio

Subsidiary: The Matteson Equipment Company, Inc., Poland, Ohio

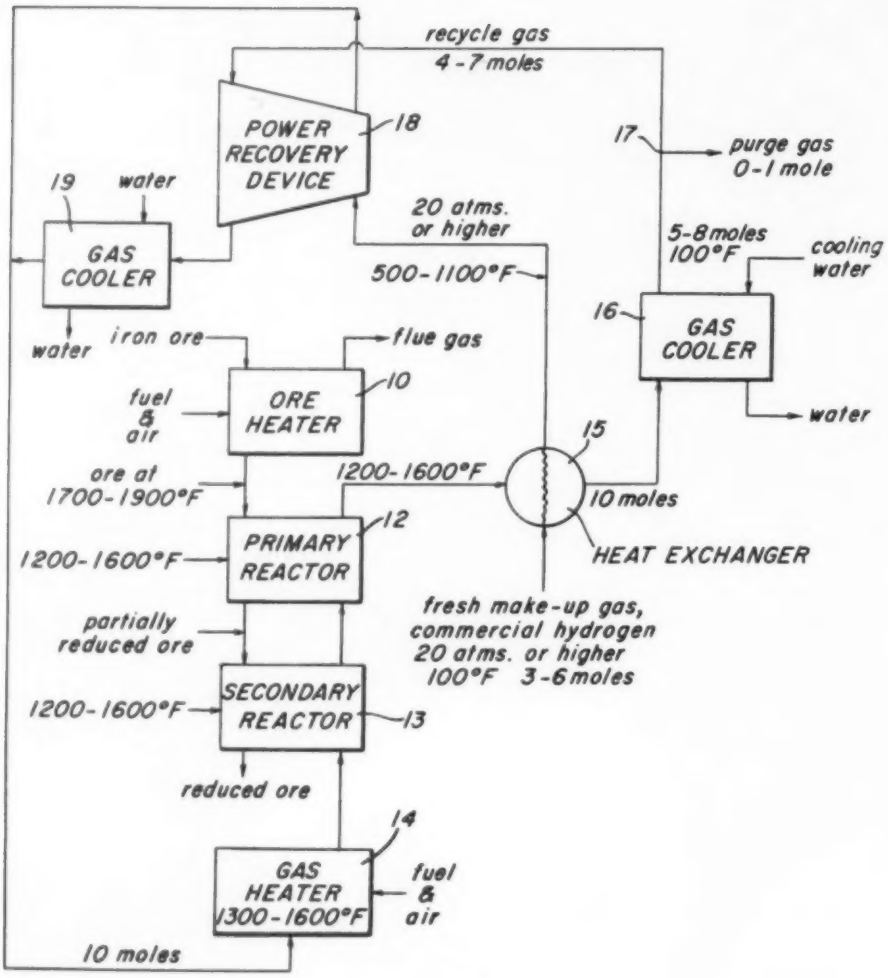


Figure 6

surize the low pressure recycled reducing gas, thereby adjusting the pressure of the reducing gas mixture fed to the reduction system to the desired level. It also provides a method of utilizing sensible heat in off-gas for preheating fresh reducing gas and at the same time increasing the efficiency at which energy can be recovered from the latter, whereby heating equipment of smaller capacity can suffice for the process.

BLAST FURNACE SALAMANDER CHARTING

△ U. S. 2,915,305, issued Dec. 1, 1959, to George H. Craig, assigned to Inland Steel Co., provides a method for charting a blast furnace salamander.

It has been discovered that the formation and shape of a salamander in a blast furnace may be charted by embedding one or more electrical resistance thermometers in the brickwork which supports the furnace hearth, and periodically determining the change in temperature at the location of the thermocouple. The temperature changes will indicate that brick erosion is progressing toward the resistance thermometer and that the salamander is accordingly enlarging.

REMOVING SULPHUR AND OXYGEN FROM PIG IRON

△ U. S. 2,915,381, issued Dec. 1, 1959, to Dieter Goerrig and Viktor Lwowski, assigned to Farbenfabriken Bayer A.G., discloses a method of removing sulphur and oxygen from pig iron, by treatment with calcium monofluoride at about 1500 to 1750C.

The reactions are:

$$2\,CaF + FeS \rightarrow Fe + CaF_2 + CaS$$
$$2\,CaF + FeO \rightarrow Fe + CaF_2 + CaO$$

NITRIC ACID TREATMENT OF STEEL

△ U. S. 2,915,420, issued Dec. 1, 1959, to Paul W. Hardy, assigned to American Can Co., provides a method of treating a corrodible ferrous metal to form on its surface a characteristic pattern indicating the areas of subsequent rusting.

It has been found that by contacting a black iron surface with a dilute aqueous solution of nitric acid for a brief period of time, thereafter rinsing the surface to remove any solution remaining on it, and then drying the surface, the stain indicates the areas of the plate surface in which subsequent rusting would occur if not treated to produce the stain. It is also found that the stain causes passivation of the surface, inhibiting subsequent rusting.

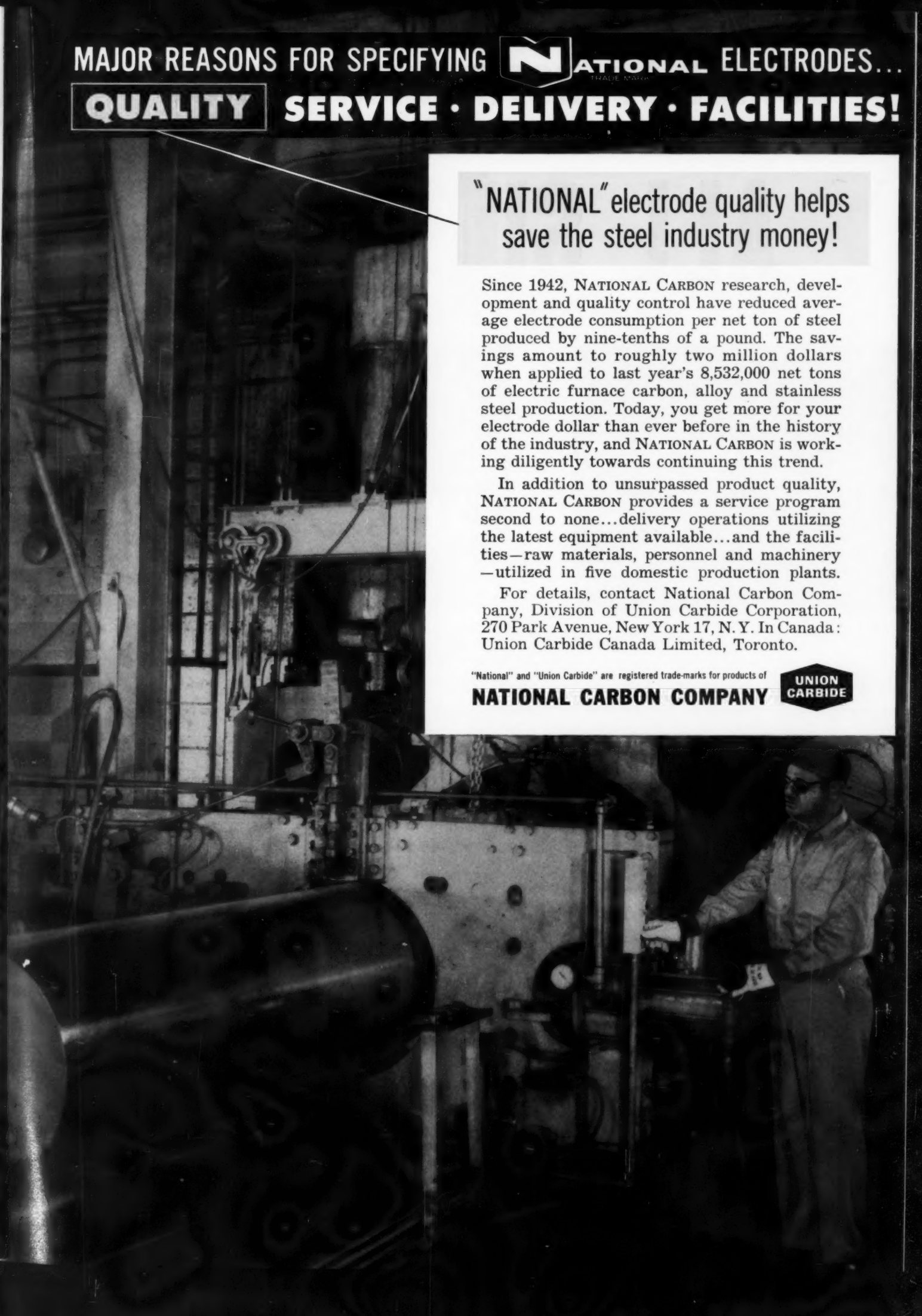
PICKLING SOLUTION

△ U. S. 2,916,458, issued Dec. 8, 1959, to Bobby L. McFarland and assigned to Aerojet-General Corp., provides a pickling solution adapted to vigorously attack high-speed alloys while having no corrosive effect upon stainless steel. It is used for removal of embedded metal objects such as broken tools from stainless steel without damage to the stainless steel.

The solution contains hydrofluoric and nitric acids.

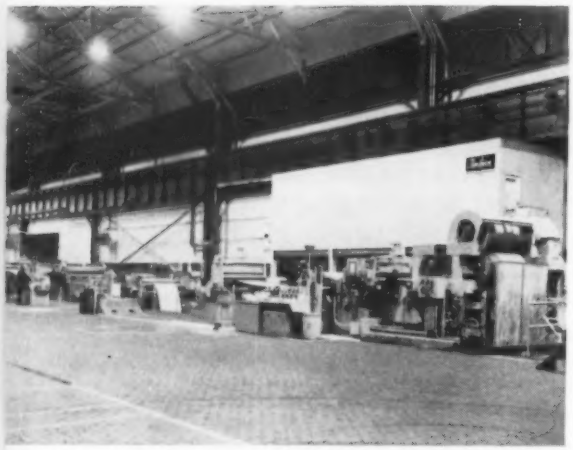
OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,915,263	12/1 /59	Track switch and rerailer	United States Steel Corp.
2,915,572	12/1 /59	Electrode regulators for arc melting furnaces	Crucible Steel Co. of America
2,916,375	12/8 /59	Alloy steels	Hadfields Ltd.
2,917,298	12/15/59	Vibratory conveyor sand seals for pusher type furnaces	Edgar H. Kendall
2,919,011	12/29/59	Ingot-handling mechanism	M. H. Treadwell Co., Inc.
2,919,039	12/29/59	Billet loader	Lake Erie Machine Corp.
2,919,041	12/29/59	Ingot stacking apparatus	Allied Steel & Conveyors, Inc.
2,919,187	12/29/59	Low-transition-temperature steel alloy	Secretary of the Navy
2,919,188	12/29/59	High strength alloy steels	Ladish Co.

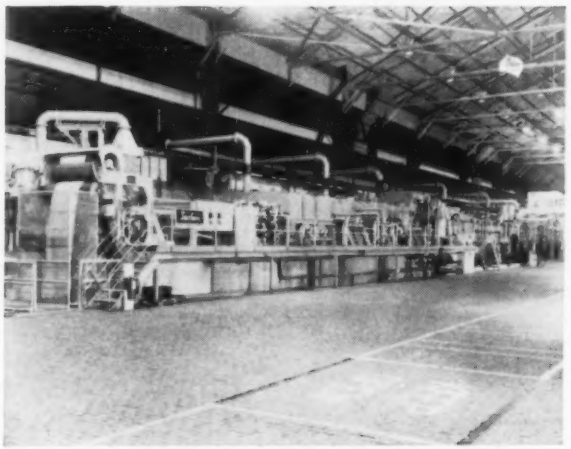

MAJOR REASONS FOR SPECIFYING NATIONAL ELECTRODES...
QUALITY SERVICE · DELIVERY · FACILITIES!
"NATIONAL" electrode quality helps save the steel industry money!
Since 1942, NATIONAL CARBON research, development and quality control have reduced average electrode consumption per net ton of steel produced by nine-tenths of a pound. The savings amount to roughly two million dollars when applied to last year's 8,532,000 net tons of electric furnace carbon, alloy and stainless steel production. Today, you get more for your electrode dollar than ever before in the history of the industry, and NATIONAL CARBON is working diligently towards continuing this trend.
In addition to unsurpassed product quality, NATIONAL CARBON provides a service program second to none...delivery operations utilizing the latest equipment available...and the facilities—raw materials, personnel and machinery—utilized in five domestic production plants.
For details, contact National Carbon Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. In Canada: Union Carbide Canada Limited, Toronto.
"National" and "Union Carbide" are registered trade-marks for products of
NATIONAL CARBON COMPANY
UNION CARBIDE

complete normalizing line:

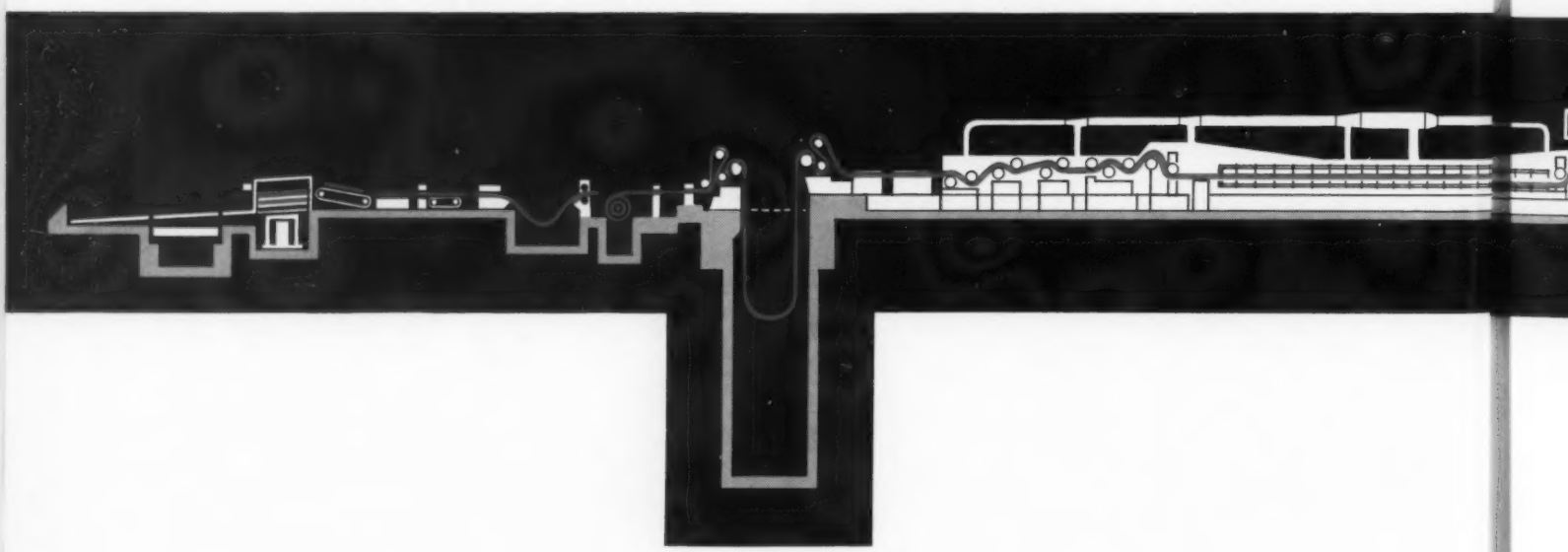
ALL SURFACE!



Exit end of the line, showing looping pit, "re-coiler," automatic shear and sheared sheet piler.

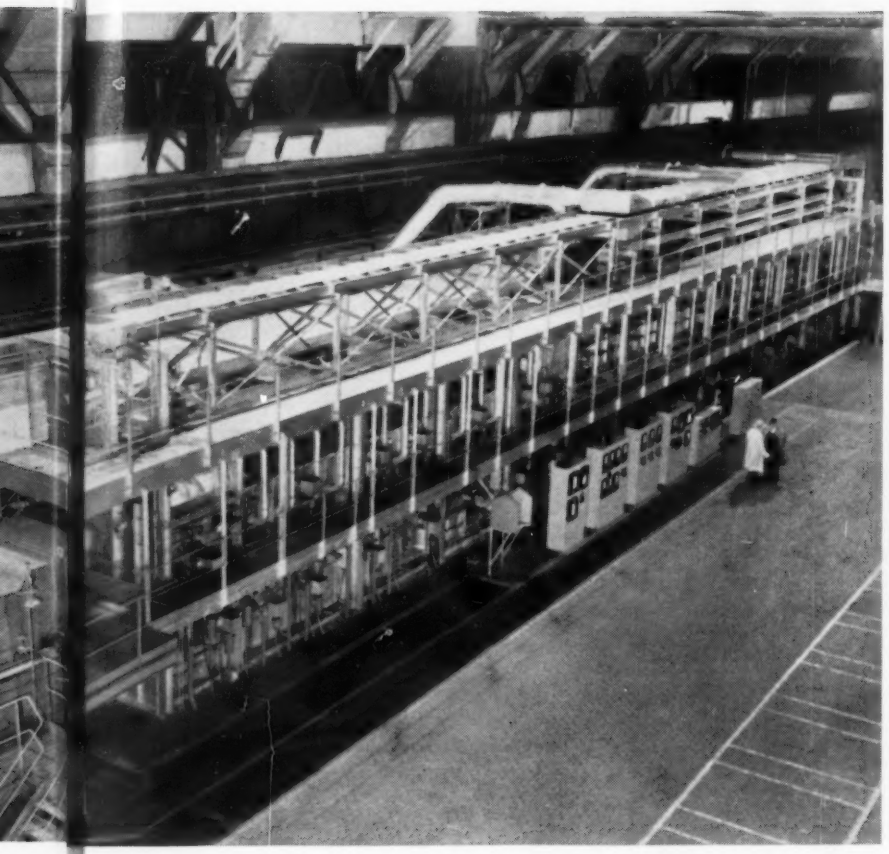


Pickling section includes acid bath, water rinse tank, brush scrubbers, alkali tank and dryer, all installed by Surface. This view shows the exit end of the section.

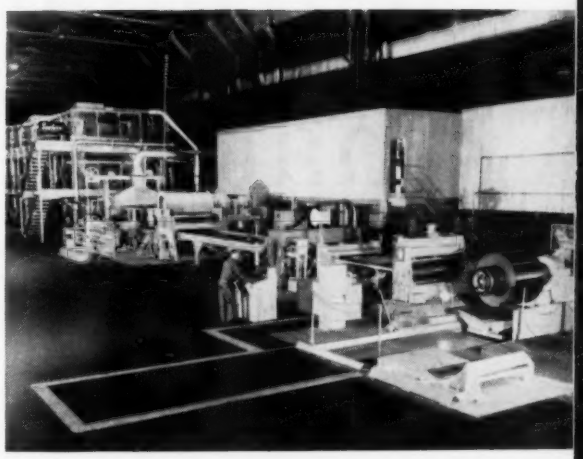


from payoff...to payoff

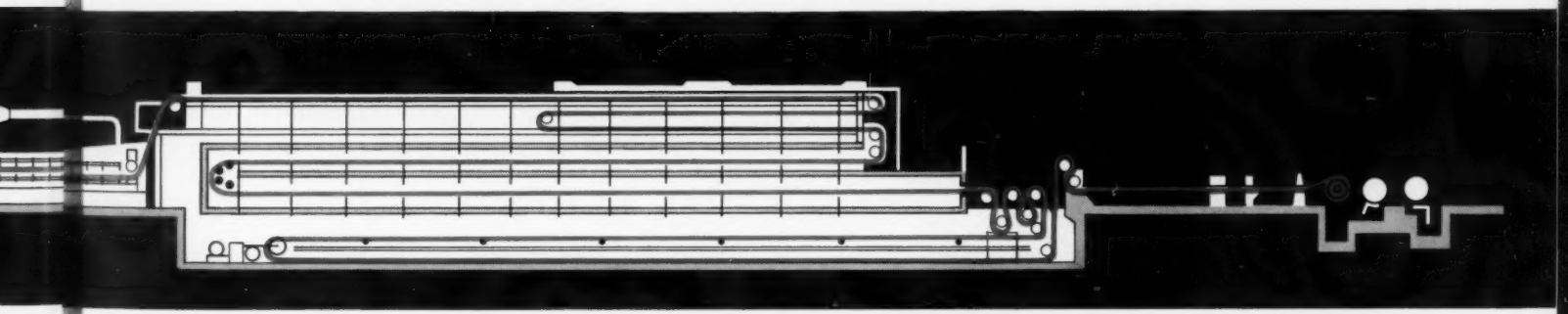
Worldwide engineering and manufacturing facilities through associates in
Australia • Belgium • France • Germany • Great Britain • Italy • Japan



Rockwells in the low 40's are achieved consistently in this three-level normalizing furnace. Heating zone is on the lower furnace level; convection cooling in the middle; air blast cooling at the top. A horizontal "looper" is located underneath the furnace.



Payoff reel marks the entry of low carbon stock after cold rolling. Speeds of 150 fpm on 60" wide strip are attained.



This complete new Surface normalizing line for vitreous enamel stock started paying off on its first day of operation. For example, its capacity of 30,000 lbs. an hour puts this mill forcefully into the market for deep draw quality strip. More than adding new selling power, this big line increased productivity per operator by an almost unbelievable amount.

From payoff reel to real payoff, the entire installation is a graphic demonstration of Surface's qualifications as prime contractor. Applying its global experience in metallurgy, combustion, chemistry, and mechanization, Surface engineered and installed the complete line.

Take the opportunity now to evaluate the prime contracting skills available at Surface, and mobilize them for your profit, ***wherever heat is used in industry.***

Surface

SURFACE COMBUSTION *2404 Dorr Street, Toledo 1, Ohio*

A Division of Midland-Ross Corporation

The warning that comes too late!

WHEN THIS HAPPENS, it's already too late. Lubricant has leaked out, and dirt or grit have probably damaged your bearings and shaft.

You can avoid sealing problems by using Johns-Manville Clipper Seals because you can count on them to outlast time between regular overhauls. They seal efficiently . . . give better protection. That's why Clipper Seals are selected as original equipment by many automotive, marine and aviation manufacturers.

JOHNS-MANVILLE PRODUCES a wide range of sizes and lip designs—including Split Clipper Seals for quick, temporary replacement – in compounds that will resist every heat, speed or corrosive condition. It is smart maintenance practice to use Clipper Seals, and to keep on hand a small replacement stock of the sizes and designs you need regularly.

Let your J-M Distributor help you select the Clipper Seals that are compounded to meet your exact sealing requirements. Or write to Johns-Manville, Box 14, New York 16, N. Y. In Canada: Port Credit, Ontario.

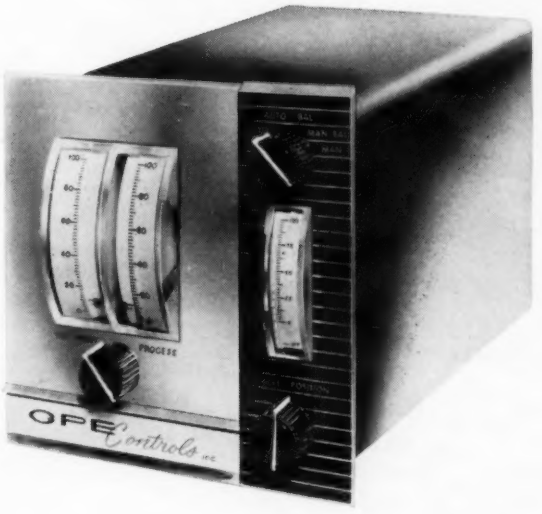
JOHNS-MANVILLE
CLIPPER SEALS

JOHNS-MANVILLE JM PRODUCTS

Electronic controllers for high-performance systems!

The new **GPE Controls** R465 Electronic Controller is built for high performance in every aspect...the result is the **highest degree of dynamic accuracy** possible. Three times as fast as other known control systems, yet comparably priced. With GPE Controls electric transmitters and electro-hydraulic valve actuators, precise control can be maintained at more than 20 cps. Easy, low-cost installation, because high-level d.c. signal makes possible simple unshielded wiring. Instant visual comparison of parallel set-point and process variable indicators.

GPE Controls R465 Electronic Controller features advanced functional design throughout. Controller drawer (left) and manual/automatic station (right) are housed in a dustproof mounting case. Either section may be serviced while the other controls the process. Proportional band, rate, and reset controls are accessible from the front while controller is operating, and are calibrated in logarithmic steps for ease in adjusting to process dynamics.



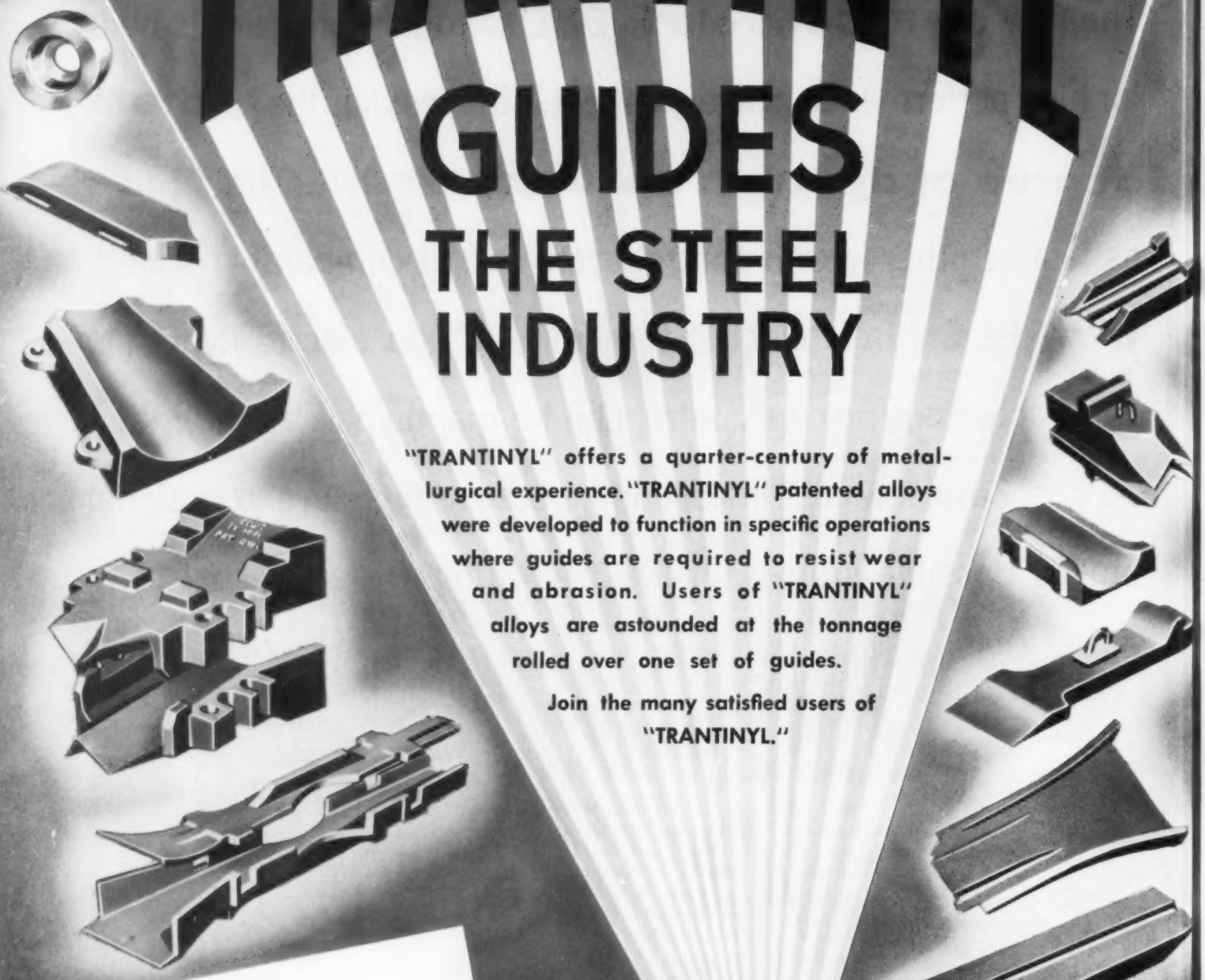
GPE Controls | A GENERAL PRECISION COMPANY

NEW factual bulletin tells the "how and why" of electronic control. Write for your copy today!

GPE Controls, Inc. (formerly Askania Regulator Company)
240 East Ontario Street • Chicago 11, Illinois

A Subsidiary of GENERAL PRECISION EQUIPMENT CORPORATION

TRANTINYL GUIDES THE STEEL INDUSTRY



"TRANTINYL" offers a quarter-century of metallurgical experience. "TRANTINYL" patented alloys were developed to function in specific operations where guides are required to resist wear and abrasion. Users of "TRANTINYL" alloys are astounded at the tonnage rolled over one set of guides.

Join the many satisfied users of "TRANTINYL."

ROLLING MILLS:
bar, hoop, strip, shape mill guides; and rollers.

SEAMLESS TUBE MILLS:
guide shoes, rolling mill plugs and rolls, piercer points, etc.

ELECTRIC WELD TUBE MILL:
forming rolls, planishing rolls, tool holders, etc.

STRAIGHTENING MACHINE GUIDES

HEAT RESISTING CASTINGS

"TRANTINYL No. 1" CAST TO SHAPE

Youngstown Alloy Casting Corporation

Youngstown, Ohio

NO PLACE TO GAMBLE...

TAPECOAT®
is Your Best Bet
to Protect Mill Lines
in Underground Service

Joints on this water line at steel plant are TAPECOATED to provide protection equivalent to coating on the pipe.

You take no chances when you specify TAPECOAT coal tar coating in handy tape form for pipe, pipe joints, fittings, couplings, tanks, tie rods and conduit on new construction, as illustrated, or for preventive maintenance on replacements.

Since 1941, TAPECOAT has proved its superiority in resisting moisture, acids, alkalis, chemical fumes and other severe corrosive and abrasive conditions.

For example, failure of a water line at an eastern steel plant in 1946 prompted this producer to turn to TAPECOAT for protecting the new line. Results were so conclusive that they have since standardized on TAPECOAT for wrapping fire prevention, water, gas and fuel lines in sizes ranging from 2″ to 48″.

TAPECOAT comes in rolls of 2″, 3″, 4″, 6″, 18″ and 24″ widths. It is easy to apply with the use of a torch. No skilled help required.

A TAPECOAT sales and service engineer is always available to help you on any corrosion problem. Write for details today.

The ***Company***

ORIGINATORS OF COAL TAR COATING IN TAPE FORM

1541 Lyons Street, Evanston, Illinois

Representatives in Principal Cities

Manufactured and distributed in Canada by The Tapecoat Company of Canada, Ltd., 25 Haas Road, Rexdale, Ontario

Generator brushes wearing too fast?

Your NATIONAL brush man showed this electroplater how to double brush life!

CLIFF BROWER

PROBLEM: Rapid brush wear was limiting generator performance.

RECOMMENDATION: "National" Brushes Grade BGX.

RESULTS: Not one commutator has been stoned or turned in five years. Brush wear has been even, with no selective action or overheating—even up to 20% overloads. Brush life has been doubled.

Contact your "National" Brush Man

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NATIONAL CARBON COMPANY
Division of Union Carbide Corporation • 270 Park Avenue, New York 17, New York
IN CANADA: Union Carbide Canada Limited, Toronto

UNION CARBIDE

Pint size...KING size...every in-between size

Bethlehem forges hardened-steel rolls of every size, shape, hardness, and finish. You can count on us for good delivery. And every roll will meet your exact specifications. Try us next time you need rolls for cold-rolling steel sheet, strip, tinplate, or non-ferrous metals.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
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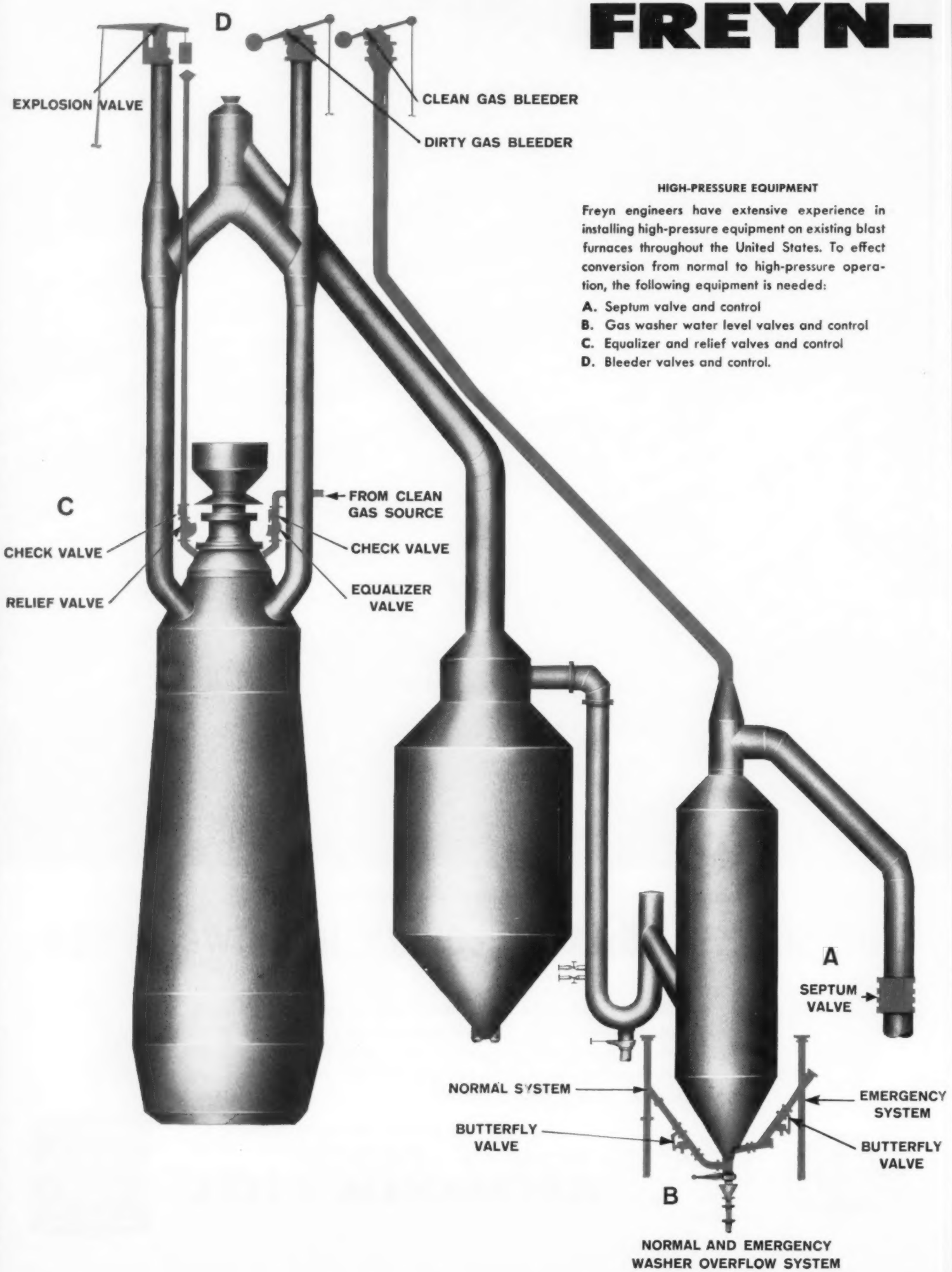
Steel
For strength
... economy
... versatility

BETHLEHEM STEEL

BETHLEHEM STEEL

FREYN-



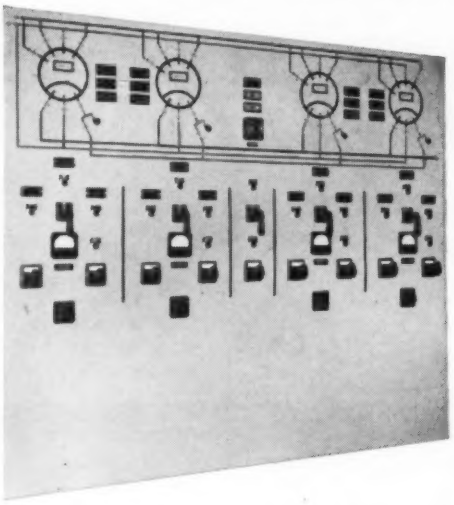
HIGH-PRESSURE EQUIPMENT

Freyn engineers have extensive experience in installing high-pressure equipment on existing blast furnaces throughout the United States. To effect conversion from normal to high-pressure operation, the following equipment is needed:

A. Septum valve and control
B. Gas washer water level valves and control
C. Equalizer and relief valves and control
D. Bleeder valves and control.

DESIGN EQUIPMENT

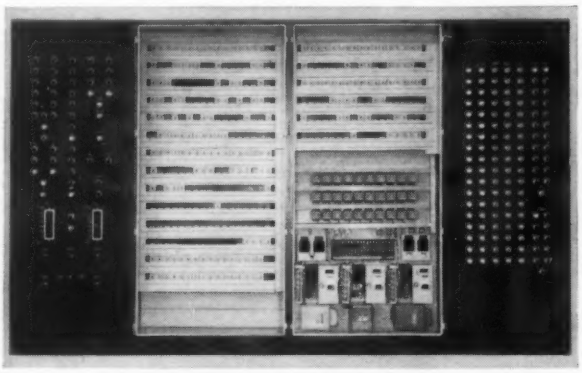
helps set new standards for blast furnace output



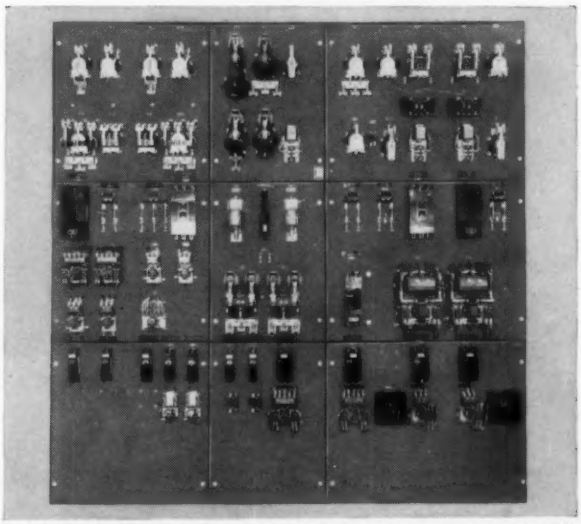
SYNOPTIC PANEL. Developed for use with completely automatic, electrically operated stove changing equipment, this master control panel is currently being installed in a large Northeastern plant. At a glance, the stove tender can quickly tell whether a stove is "on gas," "on blast," or "bottled up." Panel shows complete blast furnace piping arrangement, and is a graphic representation of the exact condition of the valves on each stove. Characteristic colors are used: Brown—stack gas; Blue—cold blast; Orange-Red—hot blast; and Yellow—gas. By pre-setting a selector switch, the stoves will be automatically changed in response to either time or temperature, without any attention from the stove tender. Provision is also made to take any one stove out of service and remain on a completely automatic sequence. Time loss in stove changing is greatly reduced.

In over 40 years as a leader in the design and construction of a complete line of blast furnace equipment, Freyn has pioneered many developments which have resulted in increased efficiency and greater output. You benefit from this unique combination of experience and service, because you know Freyn equipment can be depended upon to give you unequalled performance—with minimum maintenance and a high degree of operating economy.

In the areas of completely automatic stove changing and high-pressure furnace operations, the equipment shown here is typical of the advances in blast furnace technology constantly being sought by forward thinking Freyn engineers. For information on how Freyn equipment might improve *your* operations, write: **Freyn Department, Koppers Company, Inc., Pittsburgh 19, Pa.**



STATIC SWITCHING PANEL replaces relay sequencing control in many new and rebuilt installations. This type of control is completely static, without any interposing relays. Maintenance normally connected with relay contacts, coils and moving parts is eliminated in static switching.



MAGNETIC PANEL is required for final power output to amplify signals from static switching panel. These signals actuate the distributor motors, stockline recorder motors, and the breeze belt and vibrating screen motors. Magnetic amplifiers are utilized for control devices as solenoid valves.

Charging Control • Skip Hoist • Pneumatic Bell Hoist • Stockline Recorder • Automatic Stove Changing Equipment • Motor Drive Snort Valve Operator • Pneumatic Sludge Ejector • High Pressure Equipment • Stove Burners • Stove Valves.

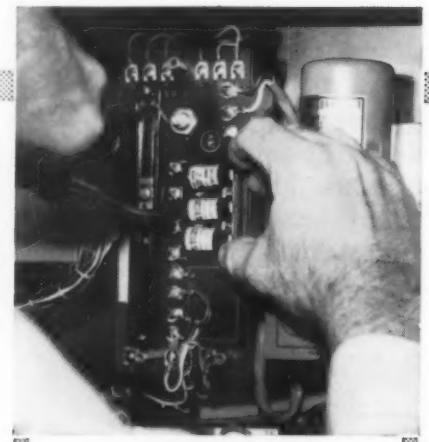
KOPPERS

KOPPERS

FREYN DEPARTMENT

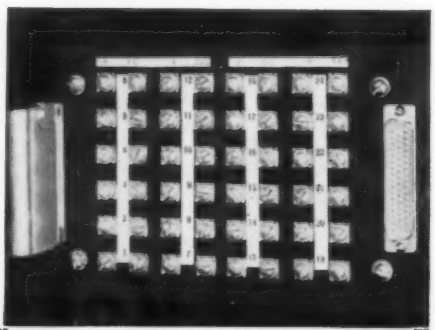
Record 2 to 24 points on the same

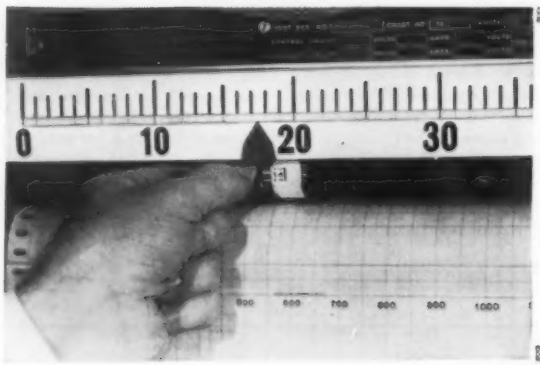
UNIVERSAL *Electronik* RECORDER



CHANGING RANGE IS EASY—Loosen screws and slide out the range resistor card. Replace with a different card, tighten screws and the job is done quickly and easily.

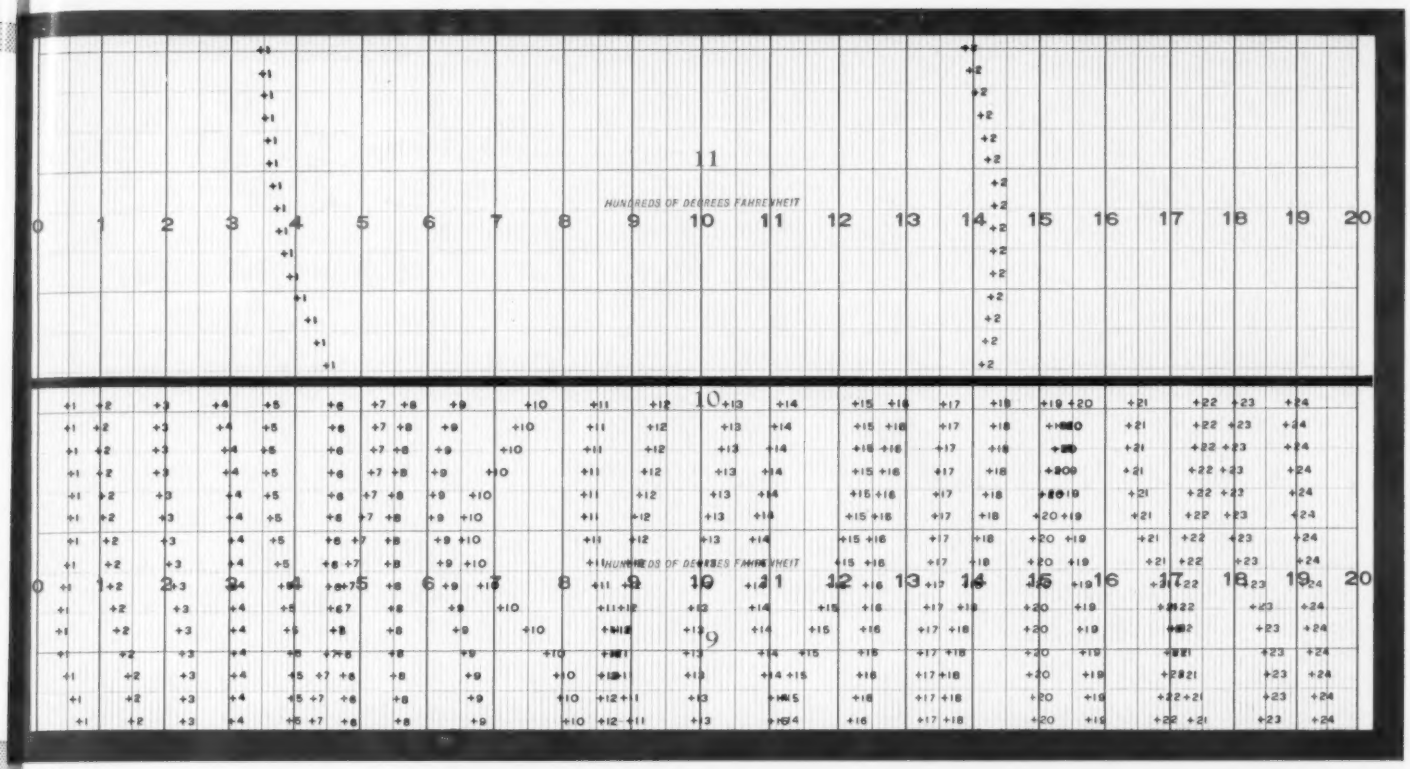
New modular design . . . and greater value than ever





CHANGING NUMBER OF POINTS IS EASY—First, remove thumb-tight nut; slip off print wheel and indicator dial. Slip on new wheel and dial and replace nut. Second, replace one plug-in unit on extreme right of terminal board, and the instrument is ready to record any desired number of points.

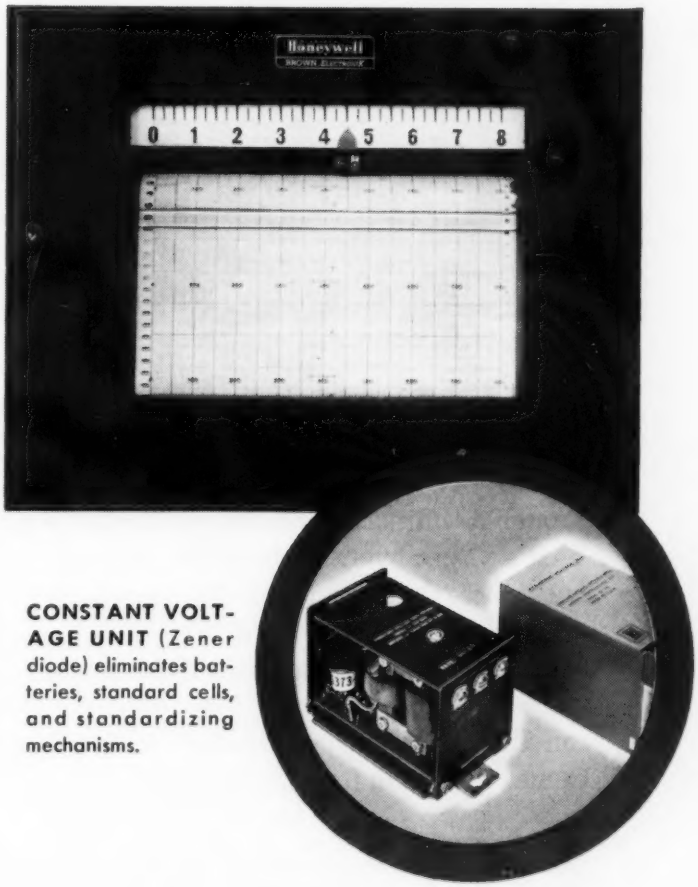
CHANGING COMPENSATION IS EASY—Input terminal board comes out by removing one plug (extreme left) and four screws. Slide in the new board, replace the screws and plug and the compensation is changed. Reference junction is built into terminal board on reverse side.



Now, you can record 2,3,4,6,8,10,12,16,20 or 24 points on one instrument—the new Universal *ElectroniK* Recorder. And you can change the number of points to be recorded in a matter of seconds. It's as easy as this: remove a thumb-tight nut and slip off the old print wheel and indicator dial. Slip on a new wheel and dial and replace the nut. Plug in the number of points wanted, and the job is done.

New modular design makes all *ElectroniK* instruments easier to use and maintain and a greater value than ever. This new design has also resulted in substantial manufacturing economies and appropriate price reductions. Get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.



CONSTANT VOLTAGE UNIT (Zener diode) eliminates batteries, standard cells, and standardizing mechanisms.

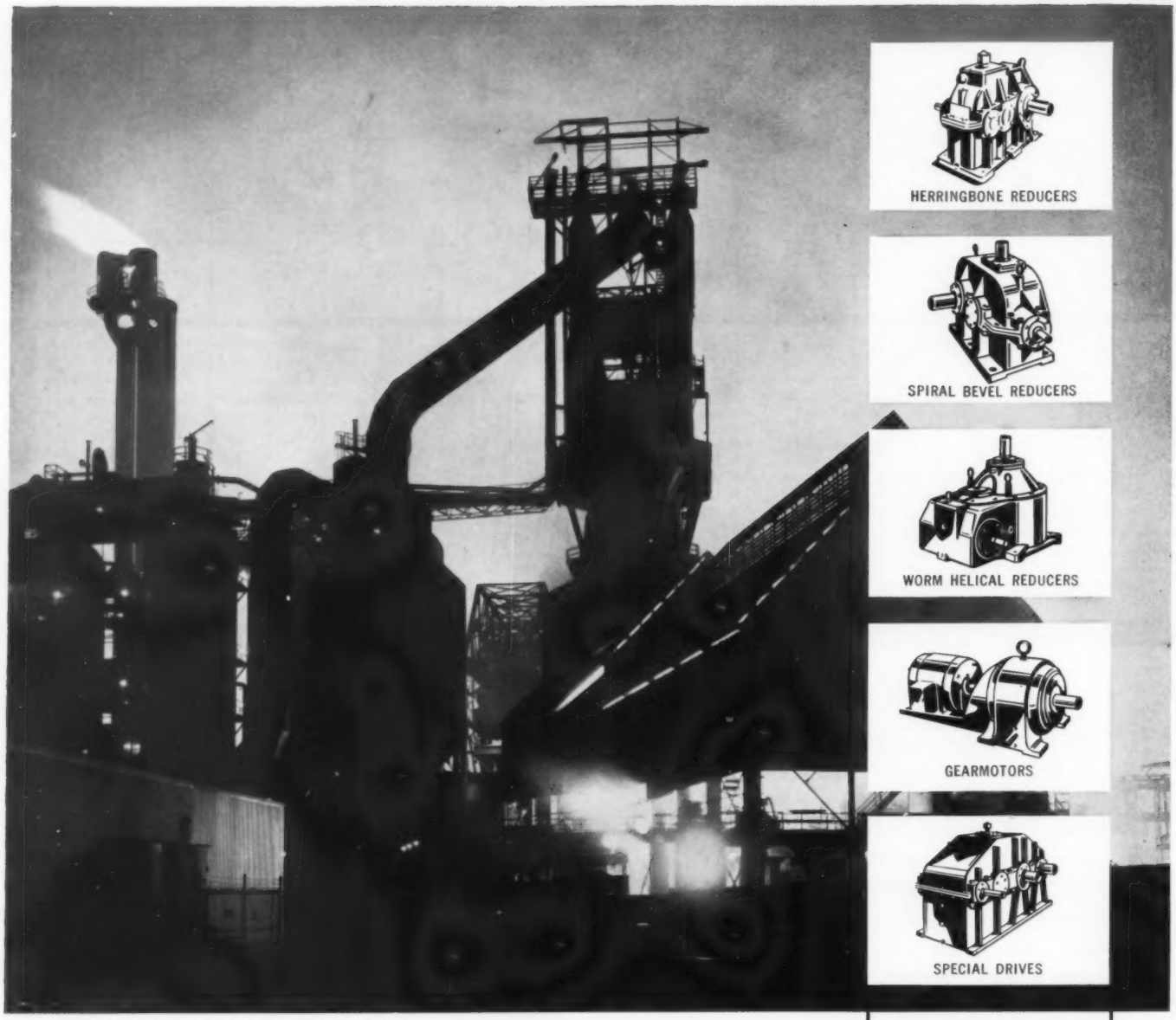
Honeywell

First in Control

SINCE 1885

75th YEAR

PIONEERING THE FUTURE



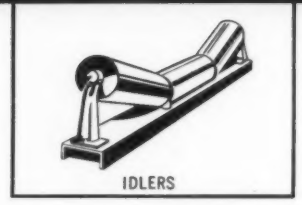
HERRINGBONE REDUCERS

SPIRAL BEVEL REDUCERS

WORM HELICAL REDUCERS

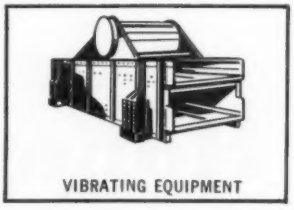
GEARMOTORS

SPECIAL DRIVES



IDLERS

CONVEYOR BELTING



VIBRATING EQUIPMENT

JONES Works for Steel Men!

From blast furnace to finishing mill, steel must move swiftly, surely. That's why so many steel men depend on Jones speed reducers. They know these rugged drives work dependably.

Jones herringbone, spiral bevel, and worm helical units—plus Jones gearmotors and special drives—comprise one of the most comprehensive speed reducer lines in the industry. For full details, consult your H-R representative, or write Hewitt-Robins, Stamford, Connecticut. Ask for Bulletin 5-50.

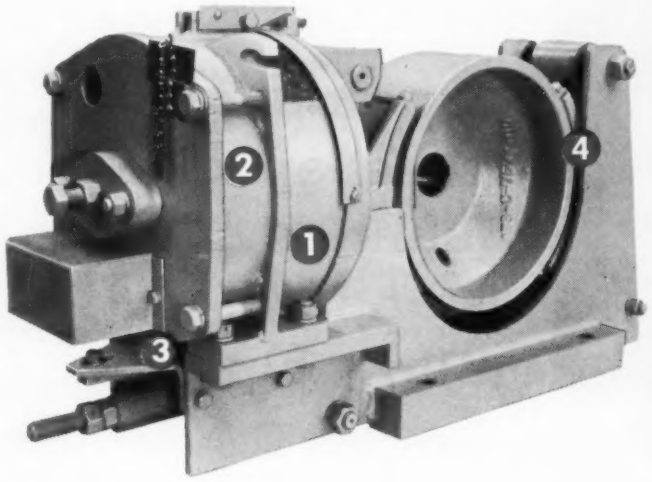
HR HEWITT-ROBINS

MEMBER OF AGMA

The name that means everything in bulk materials handling systems . . .

CONVEYOR BELTING AND IDLERS · INDUSTRIAL HOSE · VIBRATING FEEDERS, SCREENS & SHAKEOUTS · POWER TRANSMISSION EQUIPMENT

MILL-DUTY ACCESSORIES



DC BRAKES

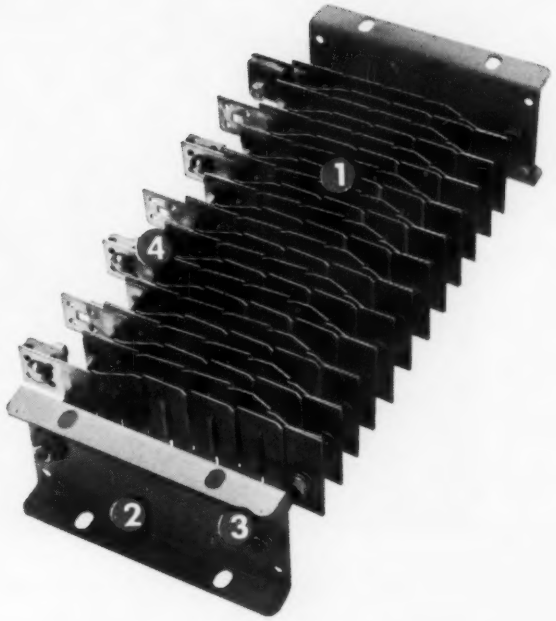
Single-end adjustment speeds maintenance and installation

New General Electric d-c brakes — featuring single-end shoe adjustment — are designed for easy maintenance and versatile installation. And, compensation for lining wear requires simple adjustment from only one end of the brake!

Here are more new features which make General Electric d-c magnet brakes your best buy for dependable, low-maintenance service:

1. **New magnet housing design** permits vertical removal, easy interchange.
2. **New coil** features all high temp. insulating materials potted in epoxy making brake ideal for the most rugged jobs.
3. **New pivot arm** assures equal shoe braking pressure.
4. **Easy lining replacement** does not require removal of brake shoe assembly . . . just lining.

Want details? See your G-E Apparatus Sales Engineer. Or, write Sect. 784-27, General Electric Co., Schenectady, N. Y., for Bulletin GEA-7067. *Industry Control Dept., Salem, Virginia.*



PUNCHED GRID RESISTORS

Designed for fast, low-cost installation

A combination of unique features makes corrosion-resistant, non-breakable, and all-welded General Electric punched-steel grid resistors easier, faster, and less costly to install. Key features are:

1. **Unique grid paralleling** saves time and expense since all parallel connections are made at factory. Grids come either series or parallel.
2. **Draw-out construction** speeds mounting in frame, assures positive alignment. Boxes are readily removed without disturbing those in place.
3. **Clip-lock and carriage-bolt fastener**— special device on runner guides locks box securely in frame. Front is bolted with only 2 self-holding bolts.
4. **All-purpose terminals** accommodate bus or cables. Taps provide means for adjusting resistance values.

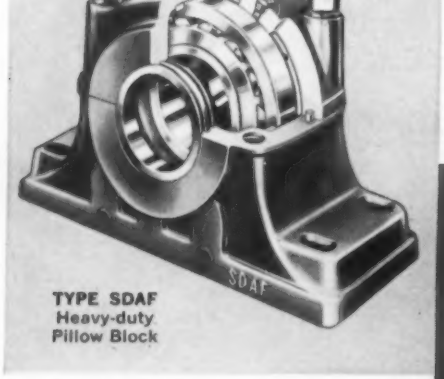
Like to know more? Contact your G-E Apparatus Sales Engineer, or write Sect. 784-27, General Electric Co., Schenectady, N. Y., for GEA-6858. *Industry Control Dept., Salem, Va.*

Progress Is Our Most Important Product

GENERAL ELECTRIC

TYPE SAF
Ball or Spherical Roller
Bearing Pillow Block

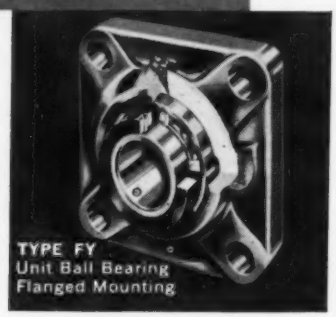
Can you get these "special" qualities in "standard" pillow blocks?



TYPE SDAF
Heavy-duty
Pillow Block

TYPE SY
Unit Ball Bearing
Pillow Block

TYPE SES
Unit Rubber-flex Ball
Bearing Pillow Block



TYPE FY
Unit Ball Bearing
Flanged Mounting

Most pillow blocks offer easy assembly and rugged housings. But can they offer you low friction, self-aligning bearing operation and efficient sealing as well?

They can—if they're the SKF pillow blocks, and flanged mounting, shown here. Type SAF, for example, comes equipped with low-friction ball or spherical roller bearings that are *inherently* self aligning. And these bearings are effectively protected by Triple-Seal rotating rings. Abrasives and corrosives can't get to them—oil or grease can't drip out.

Yet this is a standard SKF pillow block, that is competitively priced in spite of its combination of extra features. We make it for shaft sizes from ¾" to 10½", for mounting directly or with an adapter. A cast steel housing (SAFS) is available for heavy duty applications.

For details, call one of our twenty-five offices. 5938

Spherical, Cylindrical, Ball, "Tyson" Tapered and REED Miniature Bearings

EVERY TYPE—EVERY USE

SKF®

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

*REG. U.S. PAT. OFF.

BLAW-KNOX

Blaw-Knox designs and builds slabbing-blooming mills in a complete range of sizes in universal and high lift types. Other Blaw-Knox equipment for the metals industry includes complete rolling mill installations and auxiliary equipment for ferrous and non-ferrous metals, sheet and strip processing equipment, electrolytic tinning, annealing, and galvanizing lines, seamless pipe and tube mills, draw benches, and cold draw equipment, Blaw-Knox Medart cold finishing equipment, iron, alloy iron and steel rolls, carbon and alloy steel castings, fabricated steel plate or cast-weld design weldments, steel plant equipment, and heat and corrosion resisting alloy castings. Blaw-Knox Company, Foundry and Mill Machinery Division, Blaw-Knox Building, 300 Sixth Avenue, Pittsburgh 22, Pa.

46 x 90 inch Universal Slabbing Mill at the Fontana Works of Kaiser Steel Corporation.

- it's NEW
- it's SUPERIOR
- it's ACCEPTED

For Severest Roller Bearing Service

The requirement of industrial equipment for greater production creates an ever increasing demand for a superior grease. LEADOLENE 385-M is a new buttery textured grease compounded for work roll and back up roll anti-friction bearings, approach and delivery table bearings and thousands of other applications in industry.

When subjected to the most severe conditions of heavy or shock loads, LEADOLENE 385-M provides the optimum in protection against wear.

Good pumpability at low temperatures . . . protection against water and corrosion . . . excellent polarity for metal surfaces . . . worked and unworked penetration the same . . . high drop point . . . excellent shear stability . . . resists water washout . . . superior stability characteristics in service or storage . . . extreme pressure.

See the Brooks Oil man near you for important technical data and sample of this multi-purpose GREASE, or write direct to Cleveland, Ohio

* Registered

The BROOKS OIL Company
Established 1876
General offices and U.S. plant: 3304 East 87th Street • Cleveland 27, Ohio
Canadian offices and plant: 461 Cumberland Avenue • Hamilton, Ontario

The Brooks Oil International Company: Exporters

OFFICES AND WAREHOUSES
IN PRINCIPAL CITIES
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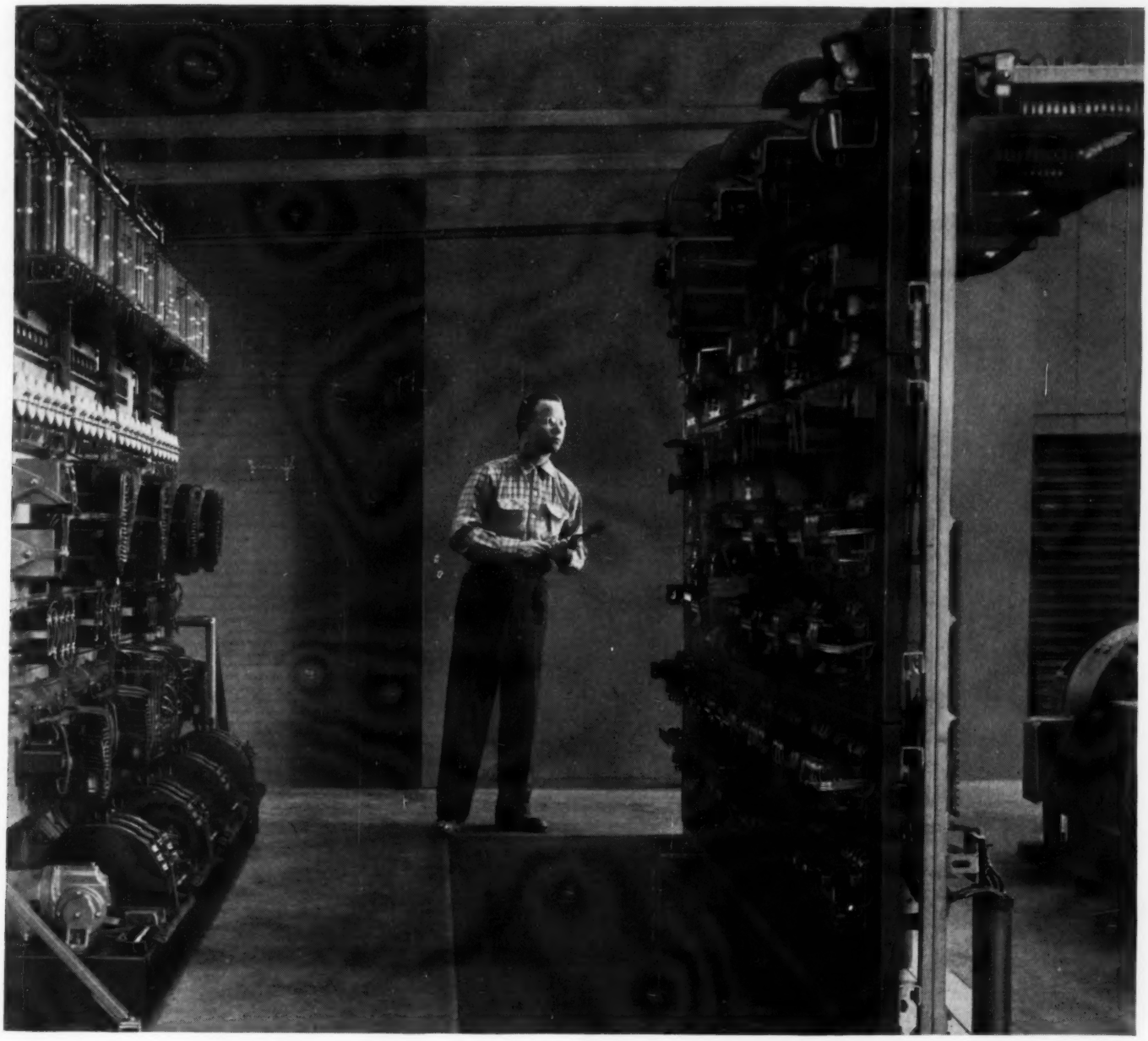
ALLIS-CHALMERS



Allis-Chalmers magnetic-amplifier regulators on a single-stand mill provide accurate tension control necessary for rolling .00035-inch foil (doubled) at 3000 fpm.

Precision control installation engineered by Allis-Chalmers ran

production foil the first day

Control systems for high-speed foil rolling applications require a high degree of engineering knowledge and skill. Allis-Chalmers coordination of design, manufacturing and installation is clearly demonstrated by results like quality production of thinner-than-paper foil on the first day of operation.

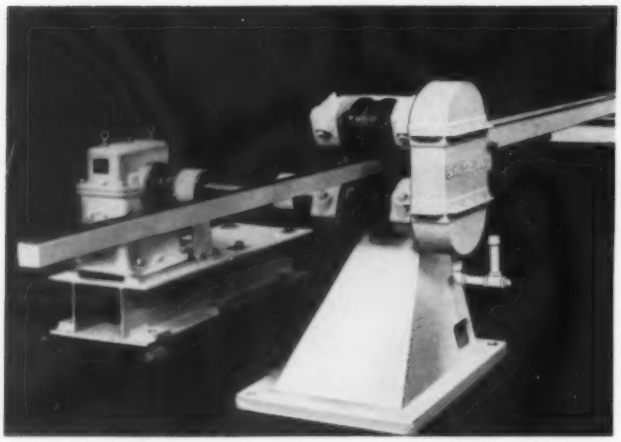
Allis-Chalmers builds control for every rolling operation . . . from the largest main mill to the smallest finishing mill.

Allis-Chalmers first developed heavy-duty control for large tandem mill drives. Now A-C applies these same high-accuracy, high-quality standards to the design and performance of control equipment for smaller installations such as single-stand foil finishing mills.

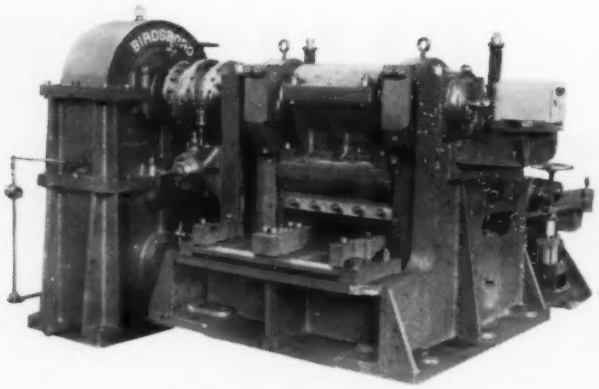
The result — regulating systems of extremely high precision . . . reliability under the most demanding production schedules.

Specify Allis-Chalmers electrical equipment on your next mill installation. Call your nearby A-C sales office or write: ***Allis-Chalmers,*** *Industrial Equipment Division, Milwaukee 1, Wisconsin.*

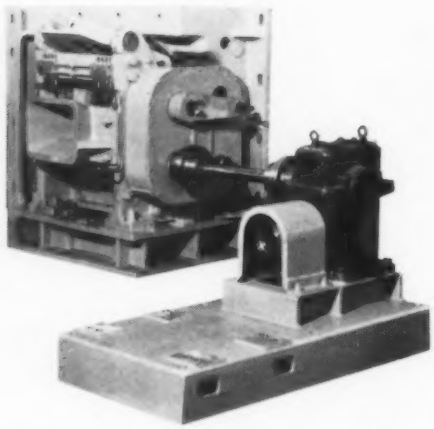
A-1281



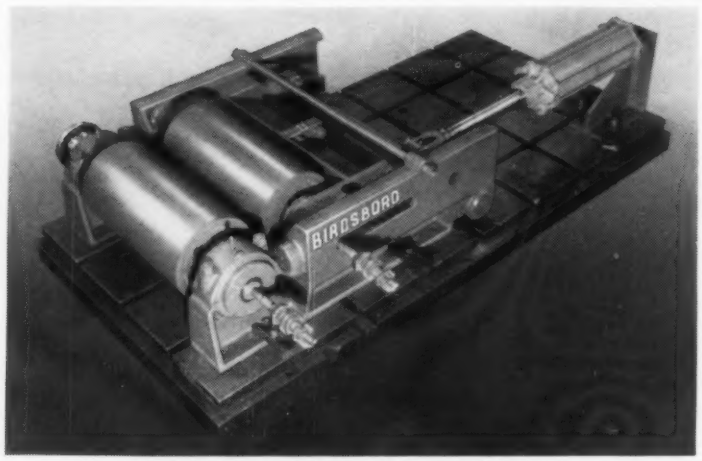
Swing type billet ejector for ejecting billets from a side discharge furnace.



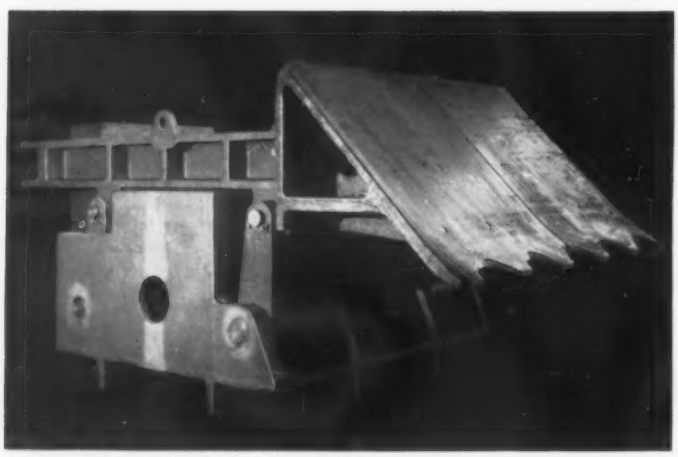
Furnace dividing shear with pinch rolls and switch for double strand mill operation.



Spring loaded discharge pinch rolls for pulling billets from furnace.

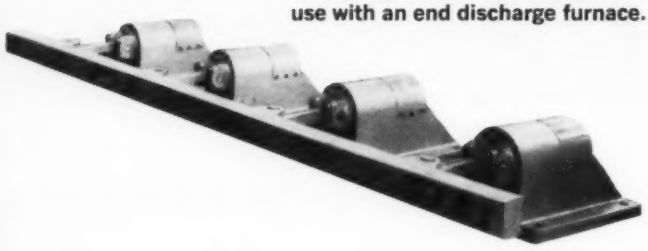


Pneumatic loaded discharge pinch rolls for pulling billets from furnace.



Heavy billet chute type spring loaded bumper for use with an end discharge furnace. The design will permit the bumper to swing clear of the table for easy table maintenance.

Spring loaded billet bumper for use with an end discharge furnace.



Furnace Discharge Equipment

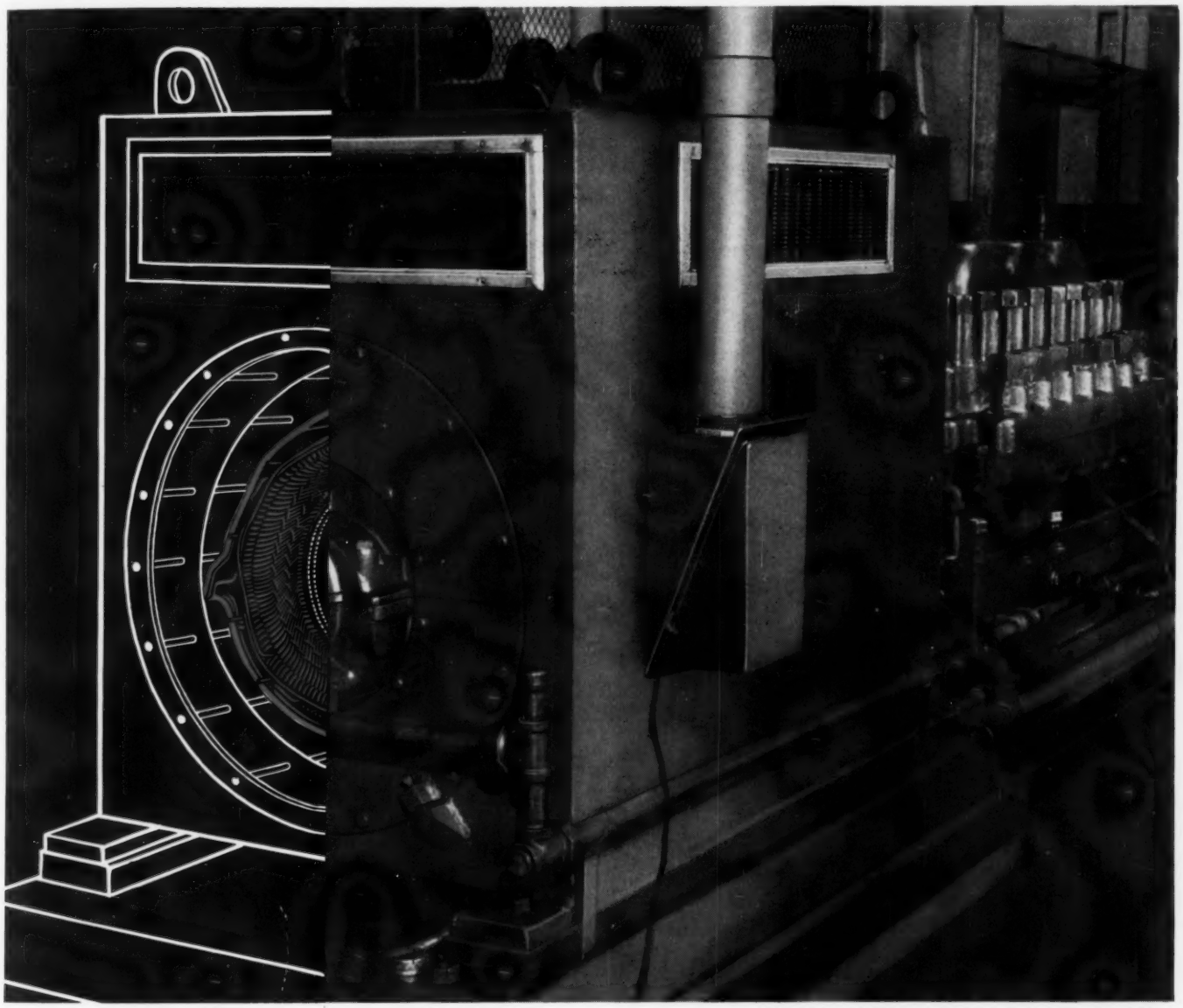
designed and built by

MM 82-60

BIRDSBORO
CORPORATION

STEEL MILL MACHINERY • HYDRAULIC PRESSES • CRUSHING MACHINERY • SPECIAL MACHINERY • STEEL CASTINGS
Weldments "CAST-WELD" Design • ROLLS: Steel, Alloy Iron, Alloy Steel • **BIRDSBORO, PENNSYLVANIA**

ALLIS-CHALMERS



Silco-Flex insulation in this descaling pump application has solved the problem of oil and extreme moisture — two of the worst enemies of motor insulation.

Your major motor investments are protected by Allis-Chalmers

invisible standards of perfection

Allis-Chalmers motors prove the value of thinking beyond established design standards. This thinking, applied to research, development and manufacturing, has led to advanced design features which mean greater application versatility, exceptional reliability and extended motor life. These are invisible standards of perfection you get with Allis-Chalmers motors.

Silco-Flex insulation, for example, has completely changed the rules on open-motor application. It is impervious to moisture, oils, and most acids, alkalies and solvents. It is resistant to abrasion, and is capable of withstanding high temperatures. Its resilience provides durability to withstand shock and vibration.

Super-Seal motors, with *Silco-Flex* insulation, have proved themselves for more than five years under the most severe conditions in industry.

Advancements such as capsule bearings, split end housings, and *Integrated* field coils (for synchronous motors) add to the superior performance of *Super-Seal* motors.

They contribute to the invisible standards that protect your motor investments year after year — cut replacement costs — assure uninterrupted production.

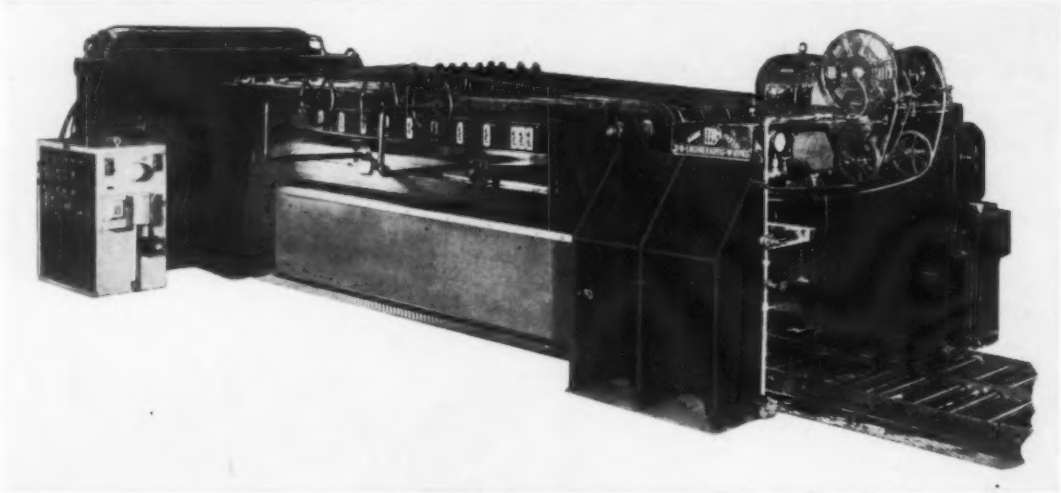
To learn more, call your nearby A-C representative, or write **Allis-Chalmers,** *Power Equipment Division, Milwaukee 1, Wisconsin.* A-1294

Super-Seal and *Silco-Flex* are Allis-Chalmers trademarks.

PRESENTING AN OLD WORKHORSE

This Bucciconi magnetic sheet piler is now ten years old. It has handled countless thousands of sheets safely and dependably in a highly productive operation.

The principles behind the Bucciconi magnetic sheet pilers are sound, practical, and proven. These machines are built not only for performance but also to stand up under the wear and tear of rugged mill condition.



74″ x 200″ Magnetic Sheet Piler

BUCCICONI ENGINEERING COMPANY INC.

PIONEERS AND MANUFACTURERS OF MAGNETIC AUTOMATION MACHINERY FOR HANDLING STEEL SHEET AND STRIP
MANUFACTURERS OF MAGNETIC CONVEYORS, MAGNETIC SHEET PILERS AND DE-PILERS, MAGNETIC ROLLS, MAGNETIC PROXIMITY INDUCTO-SWITCH, THE D. B. MICROGAGE, AND TIN PLATE ASSORTING EQUIPMENT.

899 GRANT STREET GARY, INDIANA, U. S. A.

THOUSANDS OF CUTS THROUGH STEEL RODS WITHOUT A BREAKDOWN!

Typical of the reports that come from rod and wire mills everywhere. Proof-positive that Porter has practically eliminated down-time for repairs. To cut maintenance costs and speed your cutting operations, it will pay you to get all the facts on the Porter one-hose HYDRAULIC ROD and BAR CUTTERS.

CUTTER BLADES THAT ARE REALLY RUGGED

Blades are longer . . . have *more* bearing surfaces for rigid alignment. No side thrust to cause breakage. Filtered air taken into the cylinder is forced out around the movable blade on each cut — eliminates danger of dirt reaching bearing surfaces causing oil leakage and wear.

FOOL-PROOF HYDRAULIC SYSTEM

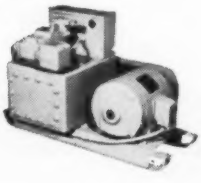
Just-one-hose design cuts replacement costs in half. Finger-tip control of cutting action! Reservoir-type 40 micron oil filter is easy to change. Adjustable relief valve saves wear and tear by providing the correct pressure for any cutting job. 12-Volt control circuit provides for operator safety.

PORTER

HKP®

ONE HOSE HYDRAULIC

ROD & BAR CUTTER



WRITE TODAY FOR ALL THE FACTS

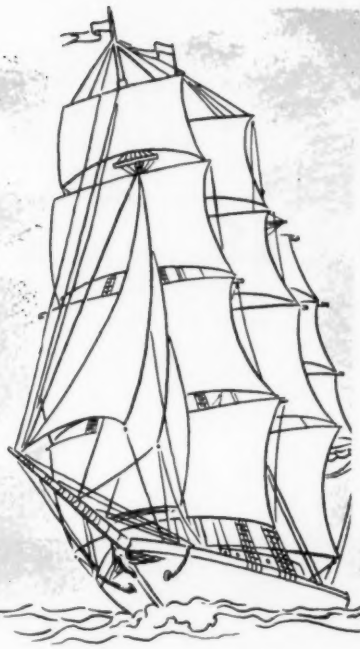
Let us show you how any combination of 3 cutter-heads for capacities up to 1⅜″ steel rods and 5 hydraulic power units can be matched to your exact requirements. Or we can design special heads for punching, crimping, heading, or forming. Write today for an on-the-job demonstration or a copy of our Rod and Bar Cutter Catalog.

H.K. PORTER, INC.,

Somerville 43, Mass.

Why Rust-Oleum is different—

and what this difference, backed by 35 years of industry proof, means to you!



A Sea Captain developed it . . . Industry proved it!

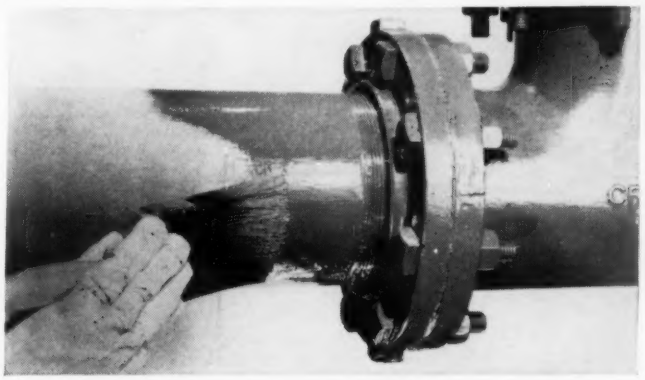
The original Rust-Oleum formula was developed nearly fifty years ago by Sea Captain Robert Fergusson, who became intrigued with the rust-stopping qualities of fish oil early in his career. Creating a *special treatment* for the fish oil, he used the *specially-processed fish oil* as the vehicle in combination with fine rust-inhibiting pigments. The result? A coating that actually *stopped rust* when applied directly over sound rusted surfaces, after scraping and wirebrushing to remove rust scale and loose rust. Possible, because the *specially-processed* fish oil penetrated the rust to bare metal. This was the birth of Rust-Oleum's *exclusive* 769 Damp-Proof Red Primer.

PROVED THROUGHOUT INDUSTRY FOR OVER 35 YEARS

Today, Rust-Oleum in its many systems and colors, has been proved throughout industry for over thirty-five years. This proof by leading industrial users is your assurance of savings in time, money, and metal. Economies made possible by the fact that Rust-Oleum 769 Damp-Proof Red Primer goes right over the sound rusted metal—usually eliminating costly surface preparations. And Rust-Oleum, in its various systems, resists rain, sun, fumes, heat, weathering, chemicals, etc., for lasting beauty over the years.

RUST-OLEUM NEW COLOR HORIZONS SYSTEM

The Rust-Oleum New Color Horizons System introduces a new coating concept to industry. It combines four important factors: (1) the ability to stop rust, (2) smart, modern color harmony, (3) the durability to last and last, (4) ease of application that saves time, money, and metal. See how this system can bring lasting beauty to your plant, machinery, equipment, pipes, tanks, structural steel, fences, etc. Write for complete information or contact your nearby Rust-Oleum Industrial Distributor. He maintains complete stocks for prompt service.



RUST-OLEUM®

There are imitations, but only *one* Rust-Oleum. It is distinctive as your own fingerprint.

STOPS RUST!®

ATTACH TO YOUR LETTERHEAD

Rust-Oleum Corporation
2648 Oakton St., Evanston, Illinois

Please send me the following at no cost or obligation:

- ☐ New Color Horizons Systems Catalog featuring 110 actual color standards and 69 photo applications.
- ☐ Free test sample of Rust-Oleum 769 Damp-Proof Red Primer to be applied over sound rusted surface.
- ☐ Results of radioactive tracing study on Rust-Oleum fish oil penetration.

SIEMENS

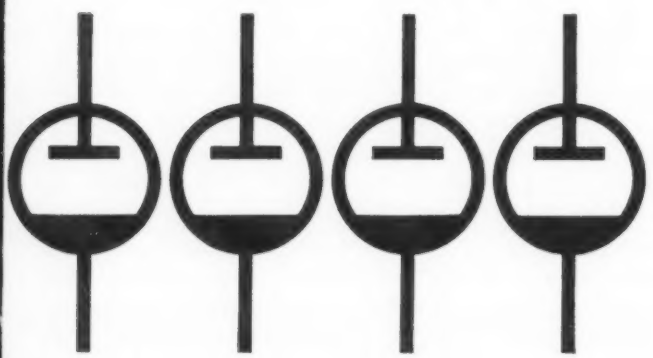
By using mercury-arc rectifiers you increase the rate of response for all rolling-mill drives

The single-anode mercury-arc rectifiers of the Siemens-Schuckertwerke for the d. c. supply of rolling-mill drives are pumpless, grid-controlled steel-tank units. They have no moving parts and operate instantaneously.

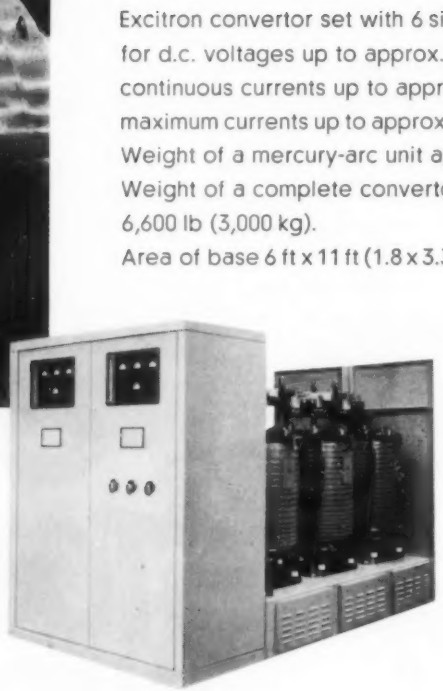
Especially in conjunction with the recently developed transistorized control and regulating equipment, therefore, the rate of response for all rolling-mill drives is considerably increased and production raised.

In addition, you also save in costs for maintenance and installation. Our single-anode mercury-arc rectifiers can be assembled on the building-block principle without special cranes and expensive foundations to form plants of any desired capacity.

18-stand continuous medium-strip rolling mill controlled by static convertors



Excitron convertor set with 6 single-anode tanks
for d.c. voltages up to approx. 1600 V and
continuous currents up to approx. 3,500 A (r.m.s.),
maximum currents up to approx. 9,000 A (r.m.s.)
Weight of a mercury-arc unit approx. 440 lb (200 kg)
Weight of a complete convertor set approx.
6,600 lb (3,000 kg).
Area of base 6 ft x 11 ft (1.8 x 3.3m)



26/57E

SIEMENS-SCHUCKERTWERKE AKTIENGESELLSCHAFT
BERLIN · ERLANGEN

Foreign Digests

Complete translations from which these condensations were prepared are available from Henry Brutcher, P.O. Box 157, Altadena, Calif., to whom all correspondence should be addressed.

"AUTOMATIC CONTROL OF BLAST FURNACE BASED ON STATIC PRESSURE DROP"

by N. N. CHERNOV, P. G. ZHIGULEV, P. G. BARANOVSKII, V. M. OBSHAROV, YU. O. RAEV and A. A. KARGIN, Siberian Metallurgical Institute, and Kuznetsk Iron and Steel Works, Stal, Vol. 18, 1958, No. 12.

Δ FAILURE of an earlier automatic control apparatus for blast furnaces, based on total pressure drop. Development of a new apparatus based on partial static pressure drops between various higher levels. Self-recorded pressure drop charts. Arrangement for cleaning sampling pipe with cooling element to ensure operational reliability of apparatus. Effect of various factors on pressure drops; pressure-drop charts for a smoothly working furnace; for hanging of stock in upper and lower furnace; for overly full hearth. Effect of charging practice on upper pressure drop. Detailed description of new system of furnace operating control based on partial pressure drops; usefulness of autoregulator with poker attachment, described, for blast furnace practice. (Translation No. 4635)

"CONTRIBUTION TO THE METALLURGY OF THE LD PROCESS"

by E. PLOCKINGER and M. WAHLSTER, Berg- und H¨ttenmänn, Monatshefte, Vol. 104, 1959, No. 10/11.

Δ PRELIMINARY brief report on results of researches conducted at the LD pilot plant at Krupps, Essen, Germany. Percentage composition of hot metal refined: 4 C, 1.5 Mn, 0.6 Si, 0.1 P, 0.05 S. Progress of reactions in a scrap-cooled heat. Reactions in heat cooled with ore + crushed limestone. Particulars on partition of manganese between metal and slag in LD process. Variation of oxygen content during refining of scrap-cooled heat. (Translation No. 4729)

OTHER AVAILABLE TRANSLATIONS

"Gas Flow in the Top-Blown Oxygen Converter," by H. A. Hashimoto, Kokura Iron and Steel Works, Sumitomo Metal Industries, Ltd., Tetsu To Hagané, vol. 44, 1958, No. 3. In the operation of a top-blown oxygen converter, flow characteristics of the molten steel, slag and gas within the vessel are important factors in the steelmaking reactions as well as in converter maintenance. These flow characteristics differ according to the shape of the vessel; alsc, the method in injecting the oxygen, i.e., intensity of the jet and location of the lance, can bring forth such changes that, in a way, it can be said that the operating efficiency of the oxygen converter may be controlled within wide limits. This paper reports the results of experiments where a model was utilized for studying the gas flow in an ordinary-shape oxygen converter under conditions where the intensity of the jet and the location of the lance have been varied. The intensity of the jet changes the flow characteristics within the oxygen converter. Therefore, it will affect the motion of the surface of the bath and the lining areas suffering damage from erosion, etc. The height of the lance nozzle does not basically change the flow within the oxygen converter; however, any increase would be similar to increasing the diameter of the jet or decreasing the intensity of the jet; also, it affects the size of the ring, the width of the flow and the surface movement. When the location of the lance is off-center, the gas flow within the oxygen converter undergoes a profound change and the places where damage occurs to the vessel lining will change correspondingly. (Translation No. 4768)

"Mechanism of Desulphurization of Pig Iron with Solid Lime," by M. I. Gromov and L. M. Tsylev, Izv. Akad. Nauk SSSR, OTN, Met. i Topl., May-June, 1959. Study of mechanism of desulphurization of iron in the presence of two solid phases: iron and lime, and in the presence of one liquid (iron) and one solid (lime) phase. Results of experiments using commercial iron sulphide, solid iron and solid lime; role played by liquid and gaseous phases; proposed scheme of mechanism of desulphurization. Desulphurization of liquid iron by solid lime: experimental setup: results of x-ray and micrographic analyses; proposed scheme. Conclusions drawn as to mechanism of sulphur removal from liquid pig iron in ladles, rotary furnaces, etc., i.e., outside the blast furnace. (Translation No. 4758)

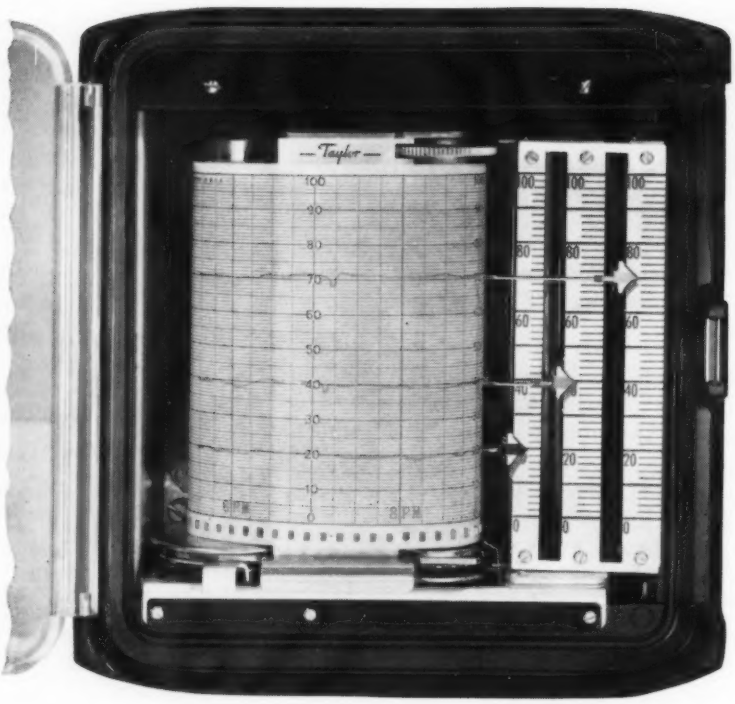
PERFORMANCE OUTSTANDING

Taylor Electronic 1, 2 or 3 Pen Recorder

HERE'S WHY:

- Takes any standard DC transmission input signals, e. g. 1-5 ma, 4-20 ma, 10-50 ma.
- Linear signal is recorded on rectilinear co-ordinates, reading left to right. Hundreds of standard charts.
- Uses DC voltages, minus 0.5 to +0.5, 0 to 1, 0.25 to 1.25 v. or any other DC voltage that can work into an impedance of 20,000 ohms per volt.
- Standard accuracy 0.5%. Optional, 0.25%. Accuracy unaffected by line voltage changes ±10%.
- Threshold sensitivity 0.1%.
- Speed of response excellent—full scale travel in less than ¾ second.
- Recorder pen can be quickly calibrated without even unplugging recorder slide.

All these advantages are made possible by use of an actual true 2-phase servo motor, coupled with a high-gain transistorized amplifier, standardized by Zener Diode voltage reference.



Available as a recording (700J) or indicating (701J-704R) control station, it also gives you these features: fastest response; bumpless capacitor gain switching; automatic stabilization during transfer; widest range of adjustments; multiple valve operation; elimination of overpeaking.

Team up the 700J or 701J with a Taylor electronic transmitter—for temperature, pressure or differential pressure.

Ask your Taylor Field Engineer for full details, or write for **Catalog 98335.** Taylor Instrument Companies, Rochester, N. Y., or Toronto, Ont.

Optional Features Available . . .

- Heavy-duty alarm contacts, 5 amps, 120 v. AC.
- 2-speed chart drive with flip of a switch. Any combination of 2, 4, 6, 9, 12, 15, 18 and 30″ per hr.; 1, 3 and 6″ per min.
- Retransmitting slide wire. (eg. for multiplication, square root extraction.)
- Will handle mv signals, 0-3 to 0-50, with 700T Pre-Amplifier.
- 24 hr. Adjust-O-Matic tear-off chart.

Taylor Instruments **MEAN ACCURACY FIRST**

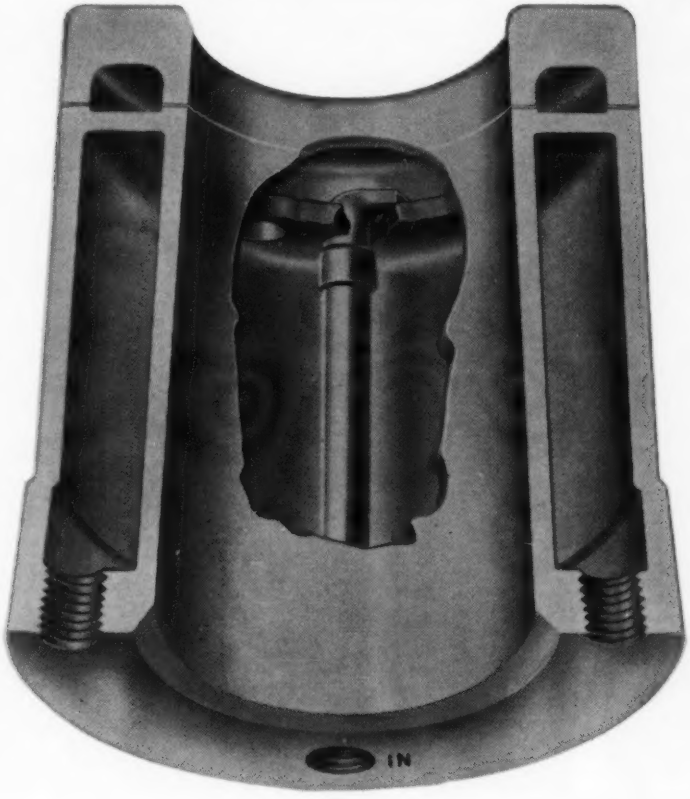
Cut furnace operating costs

Highest conductivity and advanced design of PB&B furnace copper products give better cooling, longer life

CAST COPPER
Certified 90% Minimum Conductivity

FORGED COPPER
Certified OFHC® 98% Minimum Conductivity

EBERHARDT* TUYERES



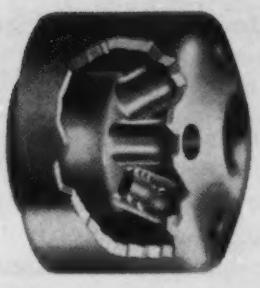
give you service-proved savings: tuyere life increased 500% . . . tuyere cost per ton of iron cut 77% . . . iron lost due to tuyere failure down 73%.

- Efficient cooling design circulates water completely around the nose section first: machined waterway gives maximum heat transfer, prevents clogging and algae build-up.
- Replaceable nose of two-piece construction lets you salvage 80% of tuyere weight when nose wear occurs.
- Highest conductivity of forged OFHC copper nose with certified minimum conductivity of 98%; cast virgin electrolytic copper body has certified 90% conductivity.

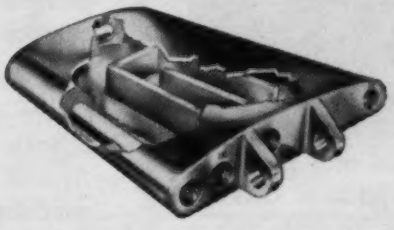
® Registered Trade Mark—American Metal Company, Ltd.

*U. S. Patent No. 2,891,783 Bethlehem Steel Company

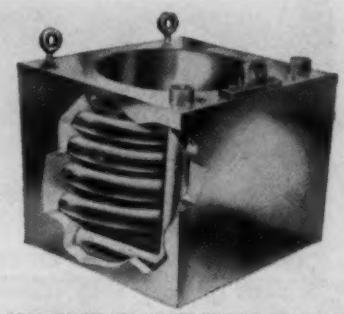
**Patent applied for



OXYGEN JET HEADS forged or cast to your specifications. Complete oxygen lances also available.



BOSH PLATES. Long life, lower maintenance assured by dual cooling chamber design. Chambers can be independently operated.



ROOF COOLERS FOR OXYGEN LANCING. High cooling efficiency comes from design with copper tubing cast into copper block.** Resists corrosion and algae build-up.

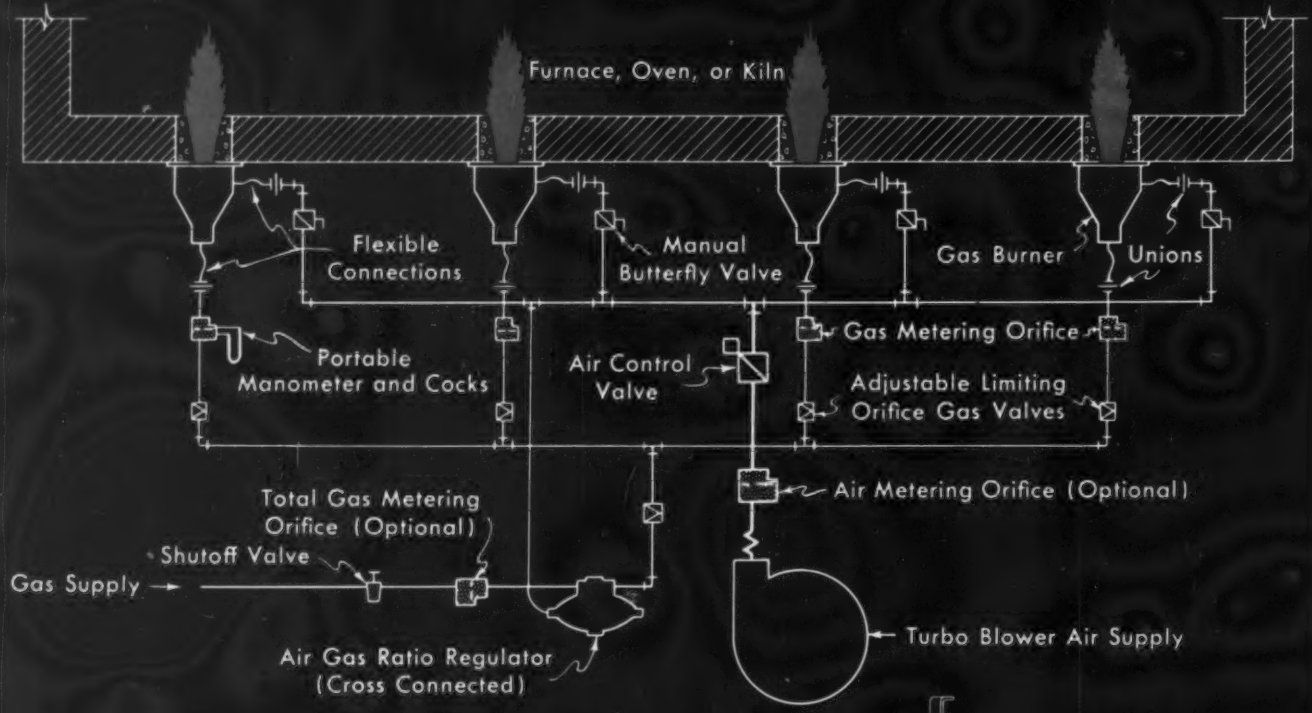
PHILADELPHIA BRONZE & BRASS CORP.
22nd and Master Streets, Philadelphia 21, Pa.

a subsidiary of

P R MALLORY & CO INC
MALLORY

OTHER PB&B QUALITY STEEL MILL PRODUCTS. Screw-down nuts for rolling mills • Slippers for universal joints on strip mill drives • Bearings for steel mill shears • Die rings • Insets • Wiping blocks • Forming rolls • Water-cooled molds

KEEP ALL FLAMES UNIFORM....



with NORTH AMERICAN'S ORIFICE METERING SYSTEM

Simple metering system. Choice of 7 precision ground orifice plates for each pipe size. Change orifices quickly with screwdriver. Portable manometer is easy to keep clean and reliable.

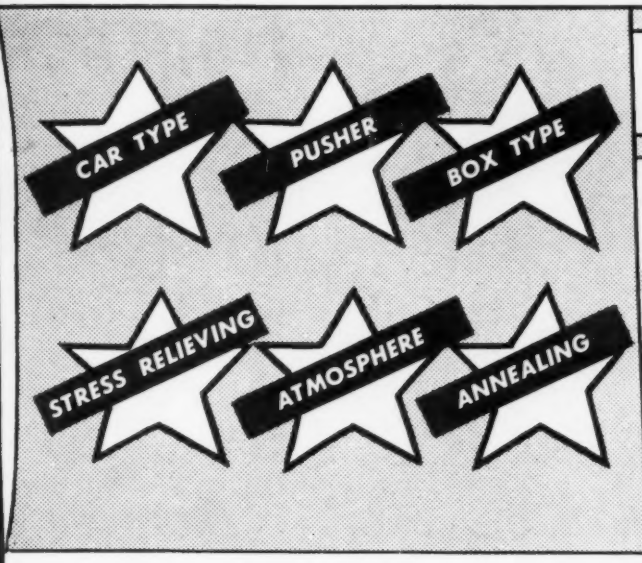
Make each burner fire at the desired rate and gas-air ratio! Use this simple and inexpensive way to accurately measure and balance gas flows to your burners.

Set burners as you wish: all alike, progressively richer or leaner, any way you choose. North American's Orifice Metering System will measure and control fuel to each burner individually or to the entire system.

NORTH AMERICAN for COMBUSTION and Hydraulic Controls

Call your nearby North American engineer or write for: Bulletin 86.97

The North American Mfg. Co.
Cleveland 5, Ohio



RAMTITE®

For Simple and Efficient Refractory Construction

. . . And for quick, easy and economical maintenance

The forge plants have the same major problems as the smelters, the steel companies, the foundries, the fabricators working with hot metal: the retention of their captive heat.

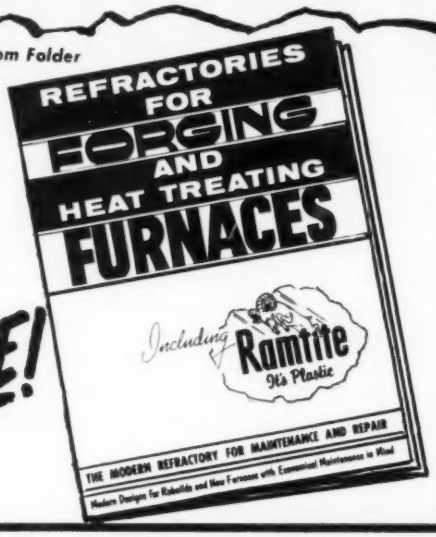
The furnaces must be air tight, gas tight, flame tight to prevent the heat escaping through porous material. So the lining plays a prominent part of the furnace yet requires a dual role. Not only must it withstand tremendous heat itself, kept constant at the high temperature while it retains the heat, but it must also stand the gaff of physical violence.

The ability to take thermal shock, expansion and contraction, erosion and corrosion are all essential attributes of any refractory. With these factors, proved by many years use in the nation's largest steel mills and forges, you are offered RAMTITE, a monolithic refractory.

RAMTITE is the common denominator for the great variety of uses in a diversity of forging, heat treating and stress relieving furnaces. Because of its ease of application and its great economy, it is used in the construction of new furnaces and is especially suitable for maintenance of other refractories, as well as RAMTITE itself.

RAMTITE is most appropriate for — and has a record of successful applications in Car Type, Pusher Box Type, Stress relieving, Atmosphere, Mandrel, Hi-heat Input, Annealing and Forge furnaces of all kinds and sizes.

Excerpt from Folder


REFRACTORIES FOR FORGING AND HEAT TREATING FURNACES
Including Ramtite It's Plastic
THE MODERN REFRACTORY FOR MAINTENANCE AND REPAIR

FREE!

Send for this NEW Folder that tells . . .

. . . how RAMTITE, the versatile, plastic refractory construction can withstand SHOCK and continuous vibration in a forge shop.

. . . how scale loss is reduced.

. . . how to save down-time in repairing box furnaces. — and RAMTITE will be most economical for new furnaces, rebuilds, repair and maintenance. It's worth getting. Mail the coupon.

The Ramtite Co.

DIV. OF THE S. OBERMAYER CO.

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THE RAMTITE CO., Div. of The S. Obermayer Co.
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☐ Send new folder: "REFRACTORIES FOR FORGING AND HEAT TREATING FURNACES" without any cost or obligation.
☐ We are interested in RAMTITE. Please furnish information.

Company Name_____

Attn. Mr._____ Title_____

Address_____

City_____ Zone____ State_____

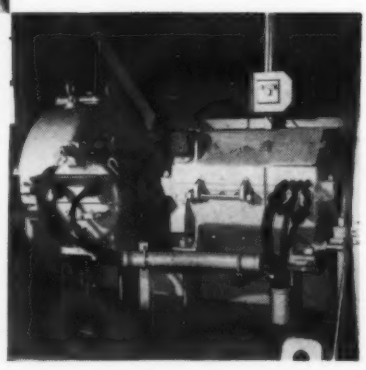
from ships

In 1904, Crocker-Wheeler introduced the first "mill type" motor—built to steel men's specifications, bull-strong, and insulated with asbestos and mica.

ELLIOTT C-W MOTORS

Above: Driving the trolley turntable is this Elliott 603 frame, 13¼-hp mill motor, seen in the foreground. In the background is one of the Elliott 616 frame, 187½-hp motors which power the trolley.

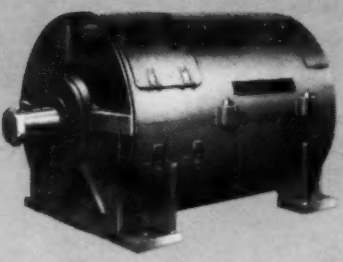
Right: One of the Elliott 612 frame, 94-hp, series-wound, adjustable-voltage mill type motors which drive the apron hoist in this gigantic operation.



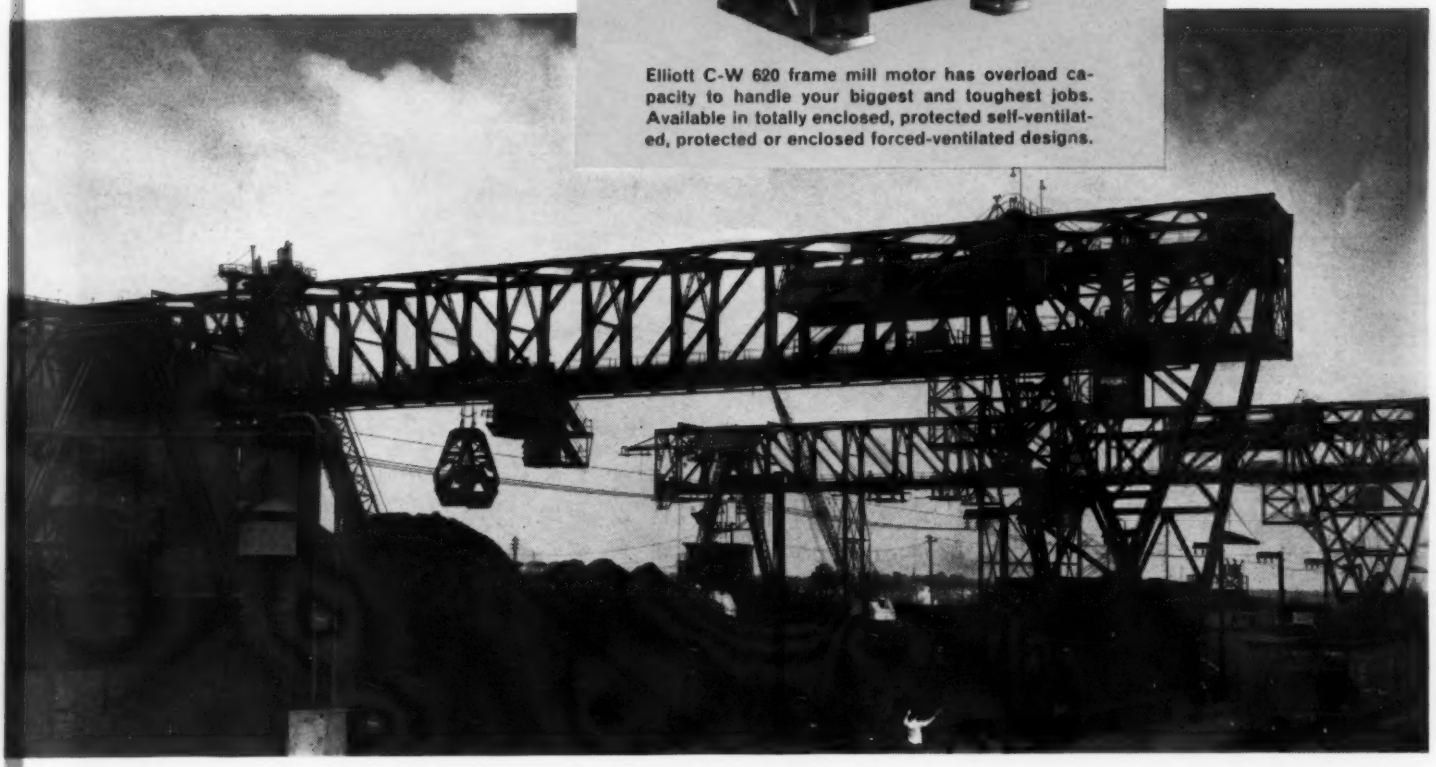
Elliott supplied all a-c and d-c motor drives, 10 to 800 hp, for the above trolley unloader. Use of d-c adjustable-voltage control on the bucket which scoops up a 22½-ton load every 45 seconds and trolley travel which transfers ore from ship to hopper assures smooth, precise control of all bridge movements. Auxiliary d-c mill motors drive the apron hoist, tower travel, rail clamp release and trolley turntable. The large, enclosed structure at the top houses mill motors, control equipment and the five-unit adjustable-voltage motor-generator set—all furnished by Elliott.

ELLIOTT
Company
Crocker-Wheeler Plant
Jeannette, Pennsylvania

to skips...

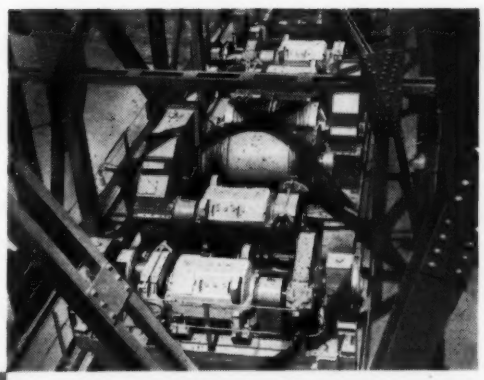


Elliott C-W 620 frame mill motor has overload capacity to handle your biggest and toughest jobs. Available in totally enclosed, protected self-ventilated, protected or enclosed forced-ventilated designs.

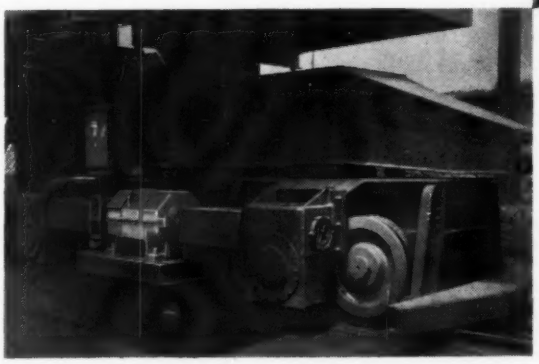


furnish the power to move mountains of ore

Elliott mill motors and motor-generator sets furnish the drives and power for the above gigantic bridges which move mountains of ore from steel mill ore yards to blast furnace hoppers, and subsequently, to skips. The mill motors, operated at double-rated voltage and double speed, are precision controlled from the operator's cab by three master switches and three foot-operated pushbuttons. All adjustable-voltage control equipment, a five-unit adjustable-voltage motor-generator set and all of the electrical drives for both bridges were furnished by Elliott Company.

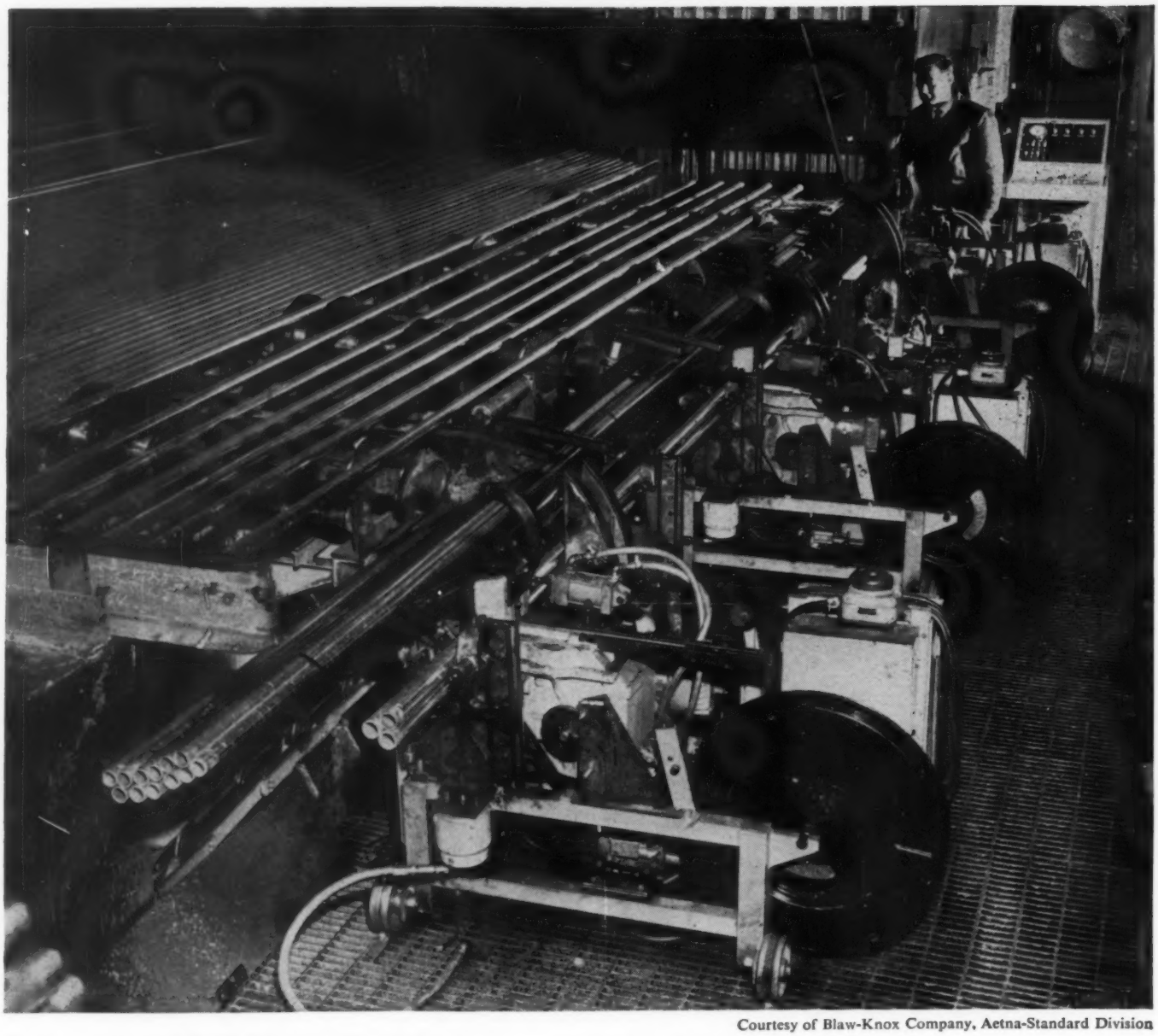


Above: The two Elliott motors nearest the bucket drums are 250-hp hoist engine drives which hoist, open and close the bucket. Identical Elliott motors adjacent to these drive the trolley along its rails.



Left: One of the twin, two-rail trucks which support the bridge pier leg. Each truck is driven by an Elliott 100-hp mill motor. The opposite, or shear leg of the bridge is supported by two sets of single-rail trucks, also driven by 100-hp motors.

W9-6



Courtesy of Blaw-Knox Company, Aetna-Standard Division

New Signode machines bundle pipe in seconds

Three synchronized Signode Model MS2BR power strapping machines are at work here. They automatically apply three straps per bundle. With these machines, it is now possible to keep ahead of the production of high speed pipe mills. Uniformly tight bundles are produced.

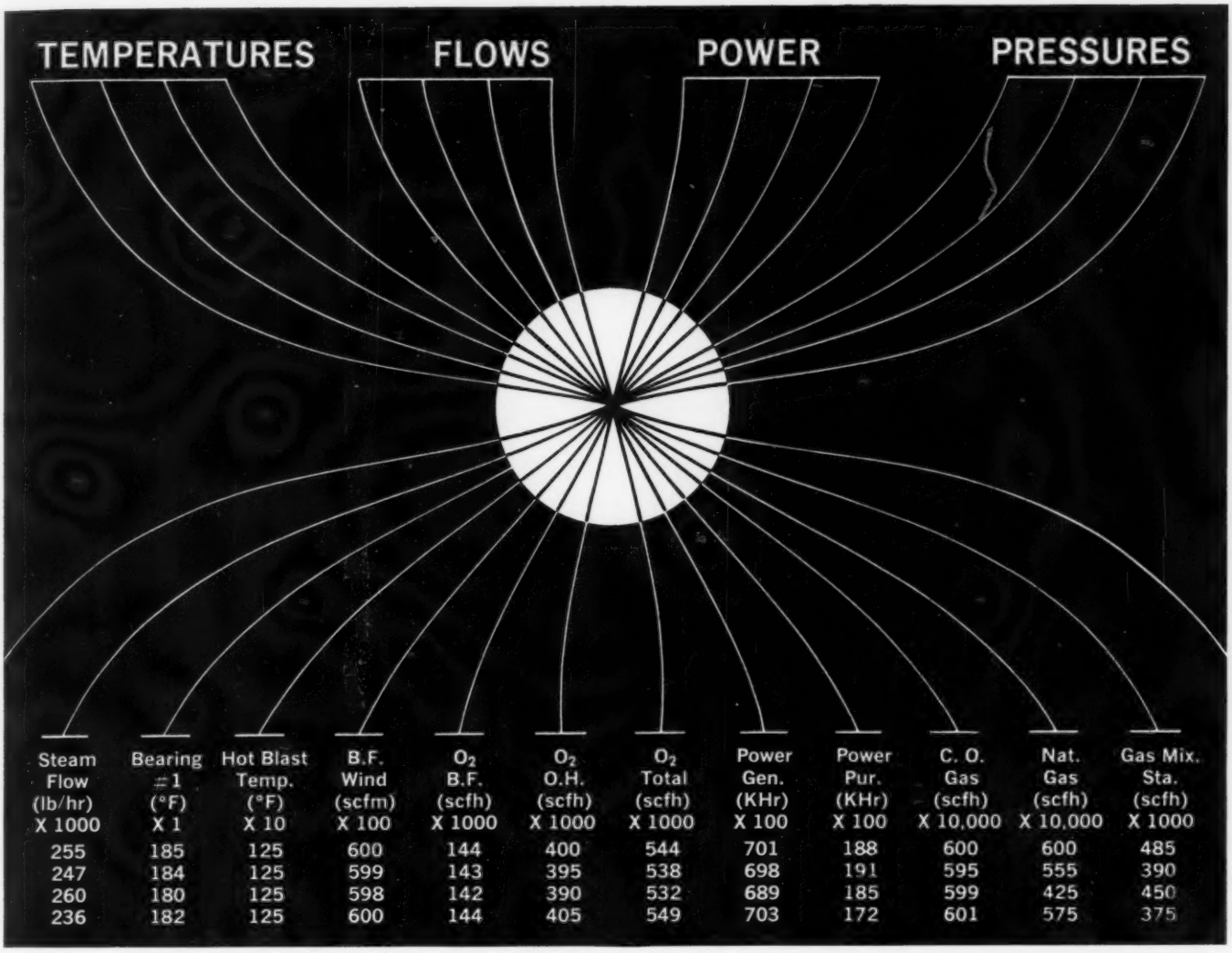
Similar Signode power strapping machines for pipe bundling have been proved dependable in more than six years of pipe mill service. They are ideal for strapping electrical metallic tubing and rigid conduit, as well as pipe. Write for more information about these machines or this installation. Signode counsel is available to help you work out a strapping installation that meets your requirements, no matter what your product. No obligation. Just write:

First in steel strapping

SIGNODE STEEL STRAPPING CO.

2644 N. Western Avenue, Chicago 47, Illinois

Offices Coast to Coast. Foreign Subsidiaries and Distributors World-Wide
In Canada: Canadian Steel Strapping Co., Ltd., Montreal • Toronto



centralized recording

with KYBERNETES Series 2000 —most flexible, all electronic data processing system

Centralized control of most steel mill processes is now available. The next step is to centralize the recording of those process variables that are important, from either an accounting standpoint, or as vital information in the control of the process. The Hagan Kybernetes series 2000 Data Processing system provides unmatched flexibility and the reliability required by industrial operations. Here are some of the reasons why Kybernetes can add to the efficiency of your operation:

- May be used for research (for example—the compiling of information on blast furnace operation) as well as for intermediate operational records.
- All variables are recorded on one or more typewritten sheets with up to 90 columns per sheet. This makes computation simple—speeds compiling of fuel reports.
- Data may be simultaneously recorded on magnetic tape or punched tape for use in computers.
- Kybernetes is the only data processing equipment on the market that provides uninterrupted alarm scanning. That is, no matter what other functions the machine is performing, scanning for off-normal conditions continues, and alarms are set off if any variable exceeds the pre-set limits.
- High accuracy with easy re-programming. Kybernetes systems provide easy change of any input, or its range. The system is so designed that spare parts stocking is minimum, and the system may be expanded to add additional inputs, or additional functions.

A Hagan engineer will be glad to explain the many labor-saving and unique advantages of the Kybernetes Series 2000 Data Processing System. Or write for Bulletin MSP 161.

HAGAN
CHEMICALS & CONTROLS, INC.
HAGAN CENTER, PITTSBURGH 30, PA.

HAGAN DIVISIONS: CALGON COMPANY—HALL LABORATORIES—BRUNER CORP.

HILL ACME ROLLS

• **HILL ACME** rolls are custom made for each application. Used in levelers, scale breakers, straightening machines, and Sendzimer rolling mills. These precision rolls are made of alloy tool steel, heat treated and accurately ground. Available in diameters to 14 inches and lengths up to 12 feet.

Standard Types:

Solid tool steel induction hardened rolls
Carborized rolls
Flame hardened rolls

Special Types:

Hollow rolls
Rubber covered rolls
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The HILL ACME Company

1201 W. 65th St., Cleveland 2, Ohio

Also manufacturers of:

HILL Grinding and Polishing Machines • "ACME" Forging Machines • "CANTON" Rotary and Alligator Shears • BAR-BILLET Shears • MATERIAL HANDLING Equipment • "CLEVELAND" Knives and Shear Blades.

SPRAYING SYSTEMS CO.

DESCALING NOZZLES

in hardened stainless steel

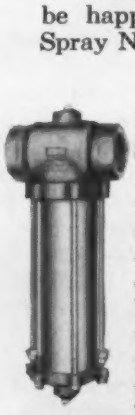
in stainless steel with tungsten carbide orifice tips

compact
modern design . . . only ½ to ⅓ the size of old nozzle types

advanced hydraulic design
gives extremely sharp, hard hitting FLAT SPRAY pattern

large open orifice
keeps clogging to a minimum

Here are spray nozzles with sharp, high-impact flat spray patterns to materially improve your descaling operations. They're small in size for easier installation and better performance. The unusually large orifices go far in solving clogging problems. Made in all capacities in hardened stainless steel for high resistance to sand and silt. And for maximum possible abrasion resistance, they're also made with Tungsten Carbide orifice inserts. Just write . . . we'll be happy to send you complete Descaling Spray Nozzle information.



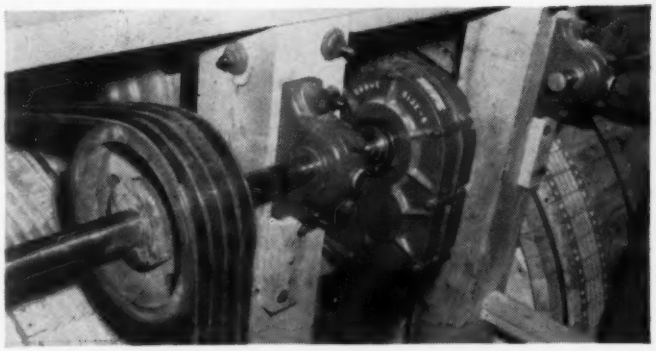
HEAVY DUTY LINE STRAINERS

Spraying Systems now offers line strainers in a full range of sizes . . . with threaded connections up to 4" N.P.T. size . . . and flanged connections in 3", 4" and 6" pipe size. Designed for operation at pressures up to 125 psi. Unusually large screen areas for high volume capacity. Heavy duty, reinforced screens. Easily flush-cleaned through bottom plug or drain cock. Write for Bulletin 94.

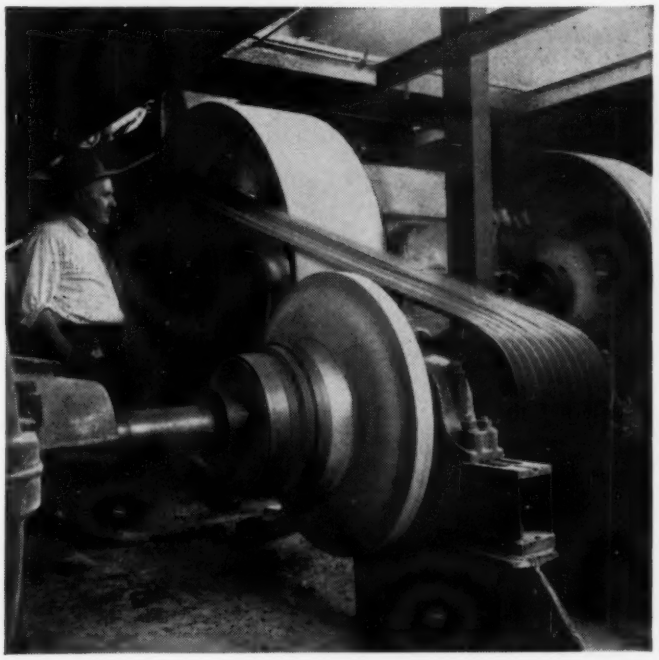
SPRAYING SYSTEMS CO.

3262 RANDOLPH STREET • BELLWOOD, ILLINOIS

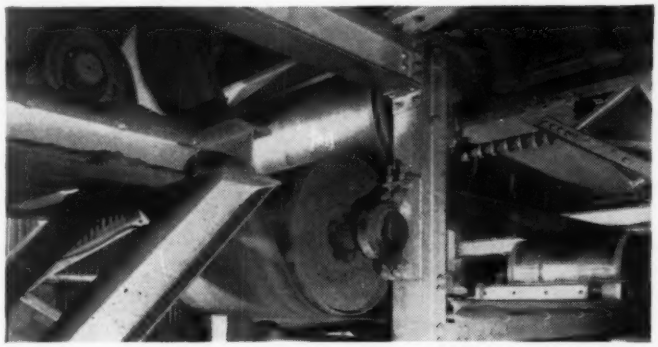
How Dodge pillow blocks with Timken® bearings give longer life with less maintenance



1. Two 2 7/16" Dodge Special Duty pillow blocks equipped with Timken® tapered roller bearings, support the line shaft driving six by eight foot tanning drums. The tapered design of Timken bearings enables them to take both radial and thrust loads in any combination.



2. The crusher at a trap rock and asphalt plant runs faster, gives more production now that Dodge Double Interlock pillow blocks on Timken bearings are installed. The Timken bearings in these blocks give full-line contact between rollers and races for greater load carrying capacity.



3. The Timken bearings in All-Steel Dodge pillow blocks must stand up under adverse operating conditions found when sintering metals. One major advantage of Timken tapered roller bearings is their ability to hold housings and shafts concentric, thus keeping lubricant in, dirt and dust out.

The photo at right shows the Dodge All-Steel pillow block Timken bearing equipped. The specially designed bearing has a tapered bore with self-aligning spherical outer surface—never needs adjustment.

There's a Dodge pillow block equipped with Timken bearings to fill every engineering need: All-Steel, Type "E", Double-Interlock, Type "C" and Special Duty. And with Timken bearings, space consuming thrust devices are not needed. Look for Timken bearings in all the machines you buy or build. They're the symbol of quality. The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.

BETTER-NESS rolls on

TIMKEN®

tapered roller bearings

Pick-up for Productivity...

Install
WAGNER *POWERED*
hydraulic brakes on busy cranes

Are shuddering, crane-wrenching stops . . . skid-by-the-spot stops . . . premature stops . . . reducing the productivity of your operation? Put an end to them. Equip your busy cranes with Wagner *Powered* Hydraulic Crane Bridge Brakes.

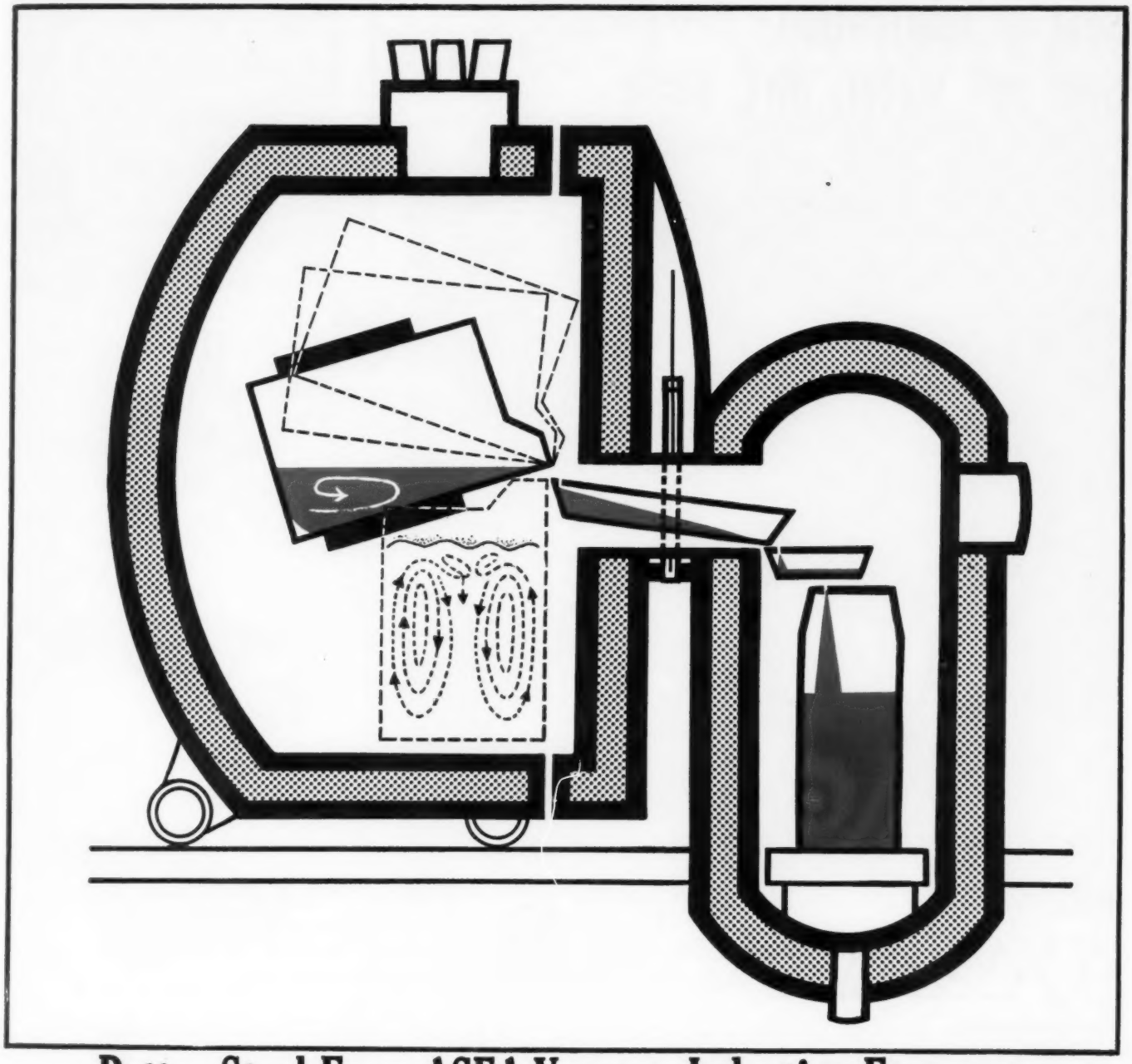
Wagner *Powered* Braking Systems reduce wear on equipment. Smooth power operation ends bridge motor plugging with its resultant damage to both motors and gears. Brakes don't drag and unnecessarily wear wheels and linings. You get safer, more efficient crane operation. Operators can stop cranes consistently and smoothly . . . productivity is increased, particularly in operations where frequent starts and stops are necessary, where close spotting is required, where heavy equipment is involved.

Your operators perform more efficiently, too, because there's far less fatigue. They can stop cranes with an easy touch of toe on a button while the heel rests comfortably on the floor. Several brakes can be operated from one station.

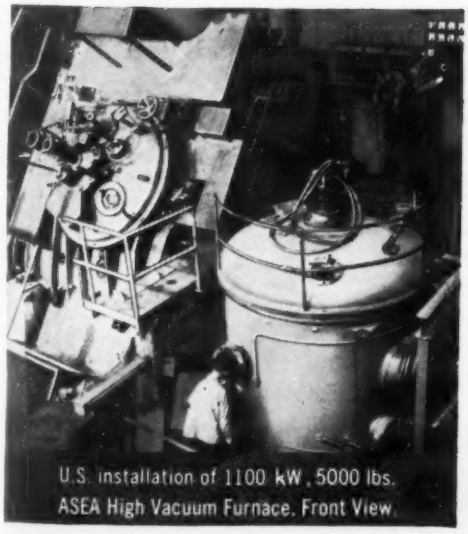
These power units can be added to your present Wagner Hydraulic System. Let your nearby Wagner Industrial Brake Application Engineer show you how easy, fast and economical such an installation can be. There are Wagner branches in 32 principal cities.

Wagner Electric Corporation
6483 Plymouth Ave., St. Louis 33, Missouri

SERVING 2 GREAT GROWTH INDUSTRIES—*ELECTRICAL • AUTOMOTIVE*



Better Steel From ASEA Vacuum Induction Furnaces

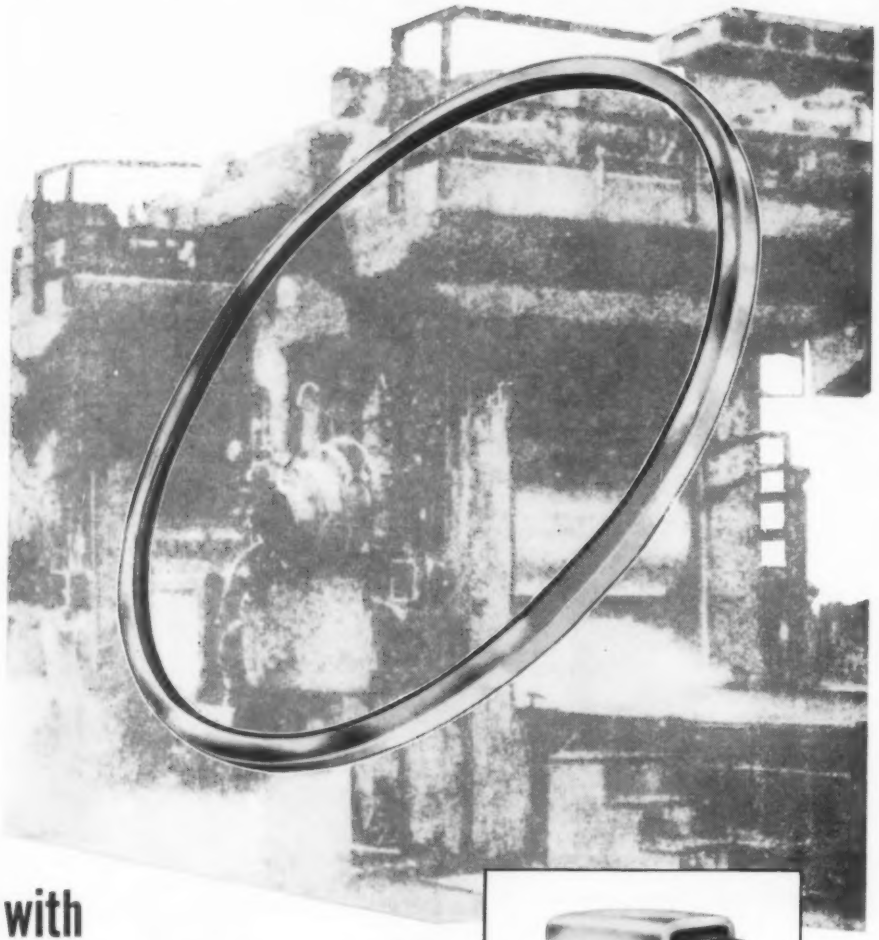


U.S. installation of 1100 kW, 5000 lbs. ASEA High Vacuum Furnace. Front View.

Induction melting in vacuum makes steel of high heat resistance, increased fatigue strength and higher yield points. In High Vacuum melting, only ASEA offers all the following advantages: ■ Accurate composition control of melt. ■ Poly-phase, low-frequency Induction Stirring increases homogeneity and purity of melt without temperature increase. ■ Accurate Temperature Control throughout process. ■ Reduced Degassing Time increases steel production. ASEA builds induction furnaces for vacuum melting up to 5,000 lbs. for air melting to 55,000 lbs. ASEA—one organization manufacturing and marketing all electrical and mechanical furnace equipment. Write for folder:

ASEA
ELECTRIC INC.
500 Fifth Ave., New York 36, N. Y.

seal in lubrication
seal out water, dirt, scale



with *SYNTRON*

Positive Sealing

ROLL NECK SEALS

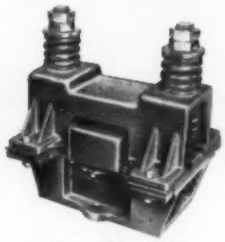
—designed to give a positive two way seal to bearings of both work and back-up rolls in strip, tempering and other rolling mills. Prevent leakage of bearing lubrication and protect bearings by sealing out spray, dirt and other foreign matter.

SYNTRON Roll Neck Seals are engineered to fit exactly—will not score roll neck—installation is quick and easy.

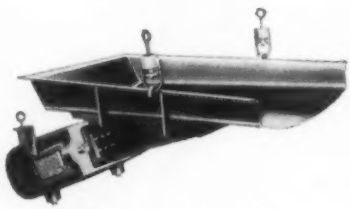
SYNTRON'S experience and know how produces the best roll neck seal available.

For complete information, write for a free SYNTRON Catalog—

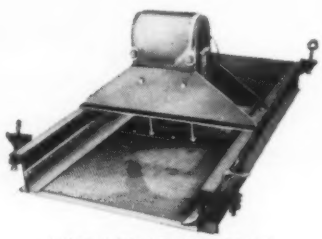
Other *SYNTRON* Equipment of proven dependable Quality



BIN VIBRATORS

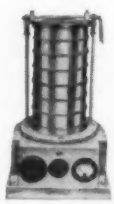


VIBRATORY FEEDERS



VIBRATING SCREENS

ROTARY VIBRATOR CAR SHAKERS



TEST SIEVE SHAKERS

SYNTRON COMPANY

699 Lexington Ave. *Quality Equipment Since 1921* **Homer City, Penna.**

Reliance Super 'T' V★S Drives

Both of these control units are rated at 50 horsepower! Actually, the new, small Super 'T' V★S cabinet packs more punch!

LIKE the Reliance Super 'T' Drive Motor, new V★S power units utilize Class B insulation, permitting a more compact unit. 100% overloads of one minute duration are accomplished without failure! Advanced design of ventilation keeps control and power units cooler . . . another reason why smaller size is possible. And service life is substantially extended.

Matched system design of drive motor, power unit and controls produces a highly efficient, integrated drive—to give you a wide range of stepless, variable operating speeds from a-c. circuits.

Super 'T' V★S Drives are available for immediate delivery. Check your Reliance salesman for delivery schedules on the full line, 1—350 hp., Bulletin Number D-2506, has been prepared to give you complete information. Write for it. D-1641

Product of the combined resources of Reliance Electric and Engineering Company and its Master and Reeves Divisions

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DEPT. 115A CLEVELAND 17, OHIO
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Duty Master A-c. Motors, Master Gearmotors, Reeves Drives, V★S Drives, Super 'T' D-c. Motors, Generators, Controls and Engineered Drive Systems.

COLMONOY® MODEL D

SPRAYWELDER

The Latest Refinement in Hard-Surfacing Equipment

Cut hard surfacing application costs and material waste with the fast-working, efficient Model D Spraywelder. It sprays over 12 pounds per hour, is up to 95% efficient. Constant development produced this new model, again proving the Spraywelder to be the one best tool of its kind. It's lighter and simpler to work than ever before, and has a large 15-lb. capacity hopper with a powder level indicator.

The Colmonoy Spraywelder produces smooth overlays of Colmonoy alloys that are fused to the base metal to form solid, welded wear resistant overlays that are easily finished, and wear up to forty times longer than hardened steel.

Write for the new Model D Spraywelder Catalog & Price List

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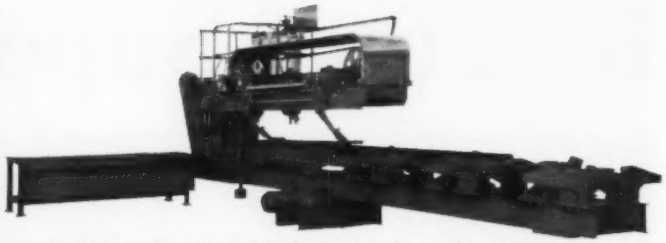

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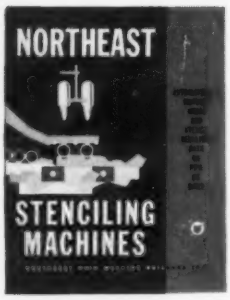

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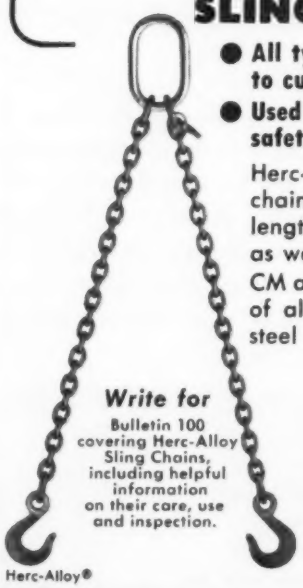

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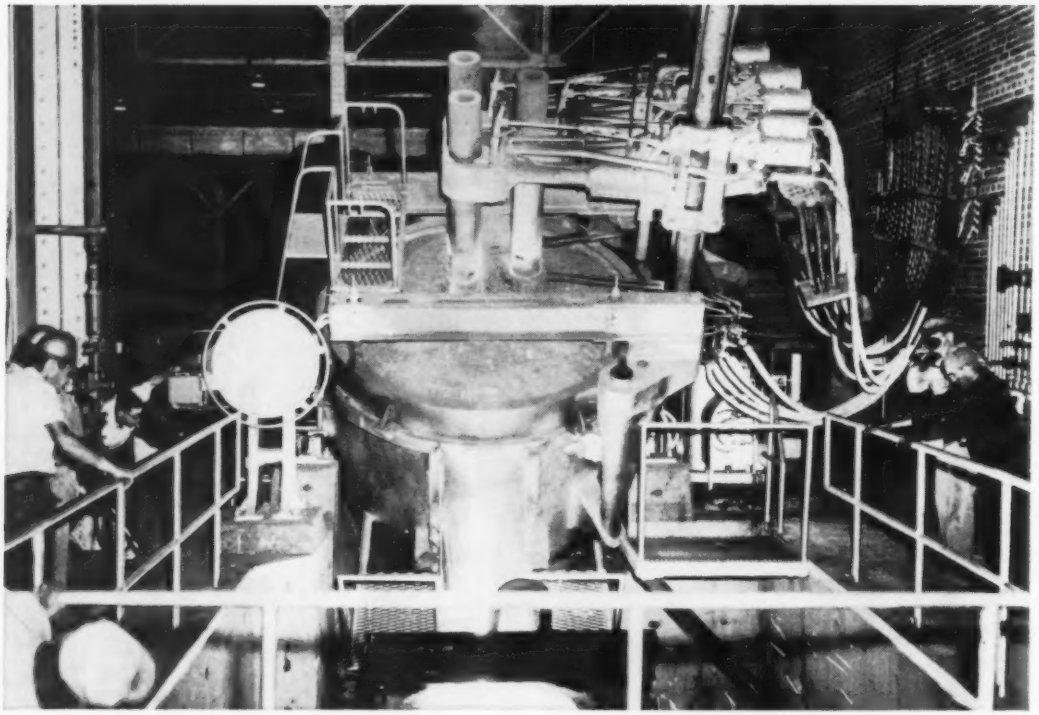

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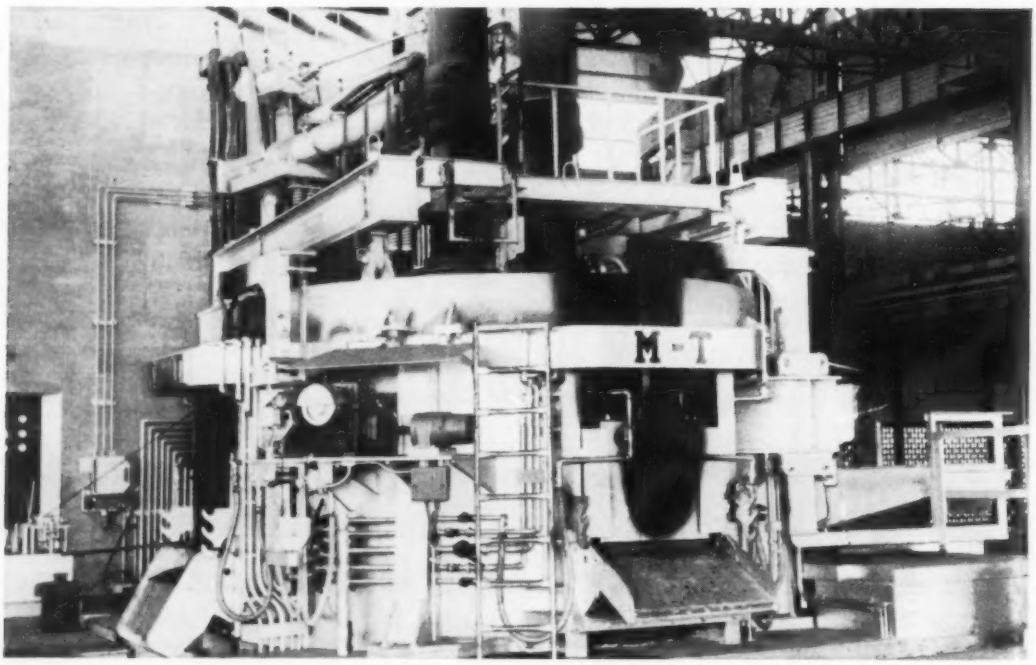

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One of the main causes of gage variation in hot strip mills is the differential between finishing speed of the last roughing stand and entry speed of the first finisher which results in temperature variations along the length of the coil . . . . variations in applied strip tension also give product variations . . . . by operating the mill with raised looper rollers and a constant small interstand tension the strip can be rolled without rapid gage changes at each end but with a small steady increase in gage from the front to back . . . . taking into account these characteristics, an attempt has been made to define conditions under which an automatic gage control will produce optimum results.

The Causes of Gage Variations In Hot Strip Mills and Their Correction

by DR. R. B. SIMS,
Chief Engineer
Research and Development
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Sheffield, England

THE purpose of this paper is to examine the causes of off-gage in hot rolling mills, and to suggest methods of correcting it within the limits of economic operation. Three types of mills will be examined; the conventional 10-stand continuous mill, the semi-continuous mill and the reversing hot mill.

A detailed mathematical treatment is not possible at present although several authors[1, 2, 3] have indicated the general method of solving the problem and have given simplified solutions for cold rolling. The mechanism of the gage changes in a multi-stand hot mill is more complex than the corresponding problem in the cold mill. Moreover few of the parameters affecting the rolled strip thickness have been measured precisely and the complete theory of hot rolling, including the method of calculating such variables as forward slip, which are important in control design,[4] has not yet been fully established. On the operational side there is, in principle at least, a wide combination of mill settings, strip dimensions, temperatures, etc., which can be used, all of which have an effect on the final gage, and which are determined for a given plant by the existing equipment and economic considerations. In this analysis, therefore, certain assumptions will be made regarding the values of the rolling parameters and the methods of mill operation based on the author's experience. Similar calculations to those given here may be made with differing parameters which suit particular operational circumstances.

* Numbers refer to Bibliography at end of paper.

THE CAUSES OF OFF-GAGE IN HOT MILLS

Strip is usually rolled in a hot mill from a slab which has, in turn, been rolled from an ingot. The slab is sheared to length, allowed to cool and scarfed to remove surface defects. The dimensions of the cold slabs are usually closely controlled; the length is dictated by the slab reheat furnace design, the width is controlled by the requirements of the customer's order and the thickness depends on the characteristics required in the finished coil. Usually slab dimensions are reasonably uniform and from the method of manufacture the characteristics of the material of the slab are constant, at least to the order of accuracy discussed here.

Off-gage, if it occurs in the resulting hot rolled coil, must therefore be due to changes in rolling conditions. From the theory of hot rolling, the factors influencing gage are: the temperature of the material and the strain rate imposed on it in the roll gap, both affecting its yield stress;[5] the roll gap settings; and the applied strip tensions.[8] So far as is known the coefficient of friction between the hot metal and the rolls is very nearly constant,[5] with the frictional forces close to the shear strength of the material at the surface, so that in hot rolling there should be no phenomenon equivalent to the frictionally induced speed effect in cold rolling,[7]

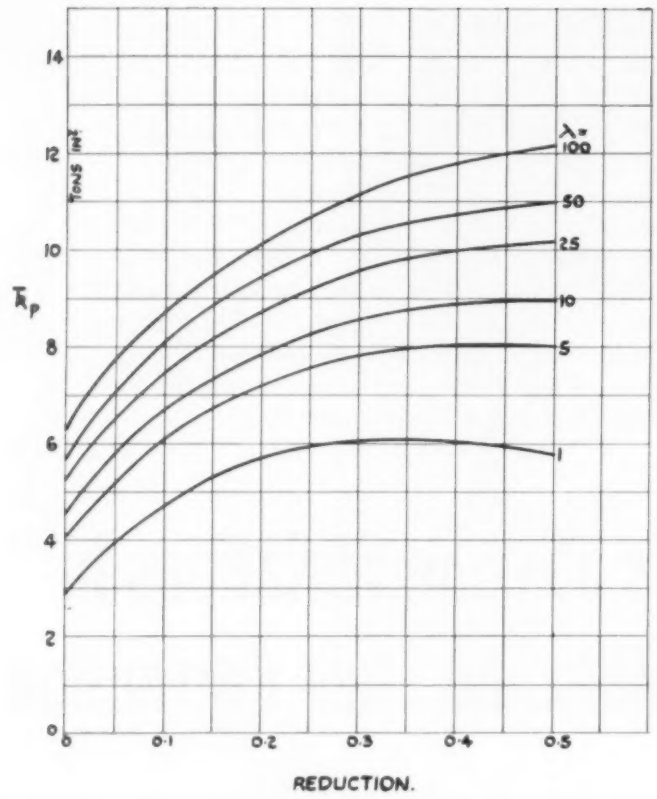
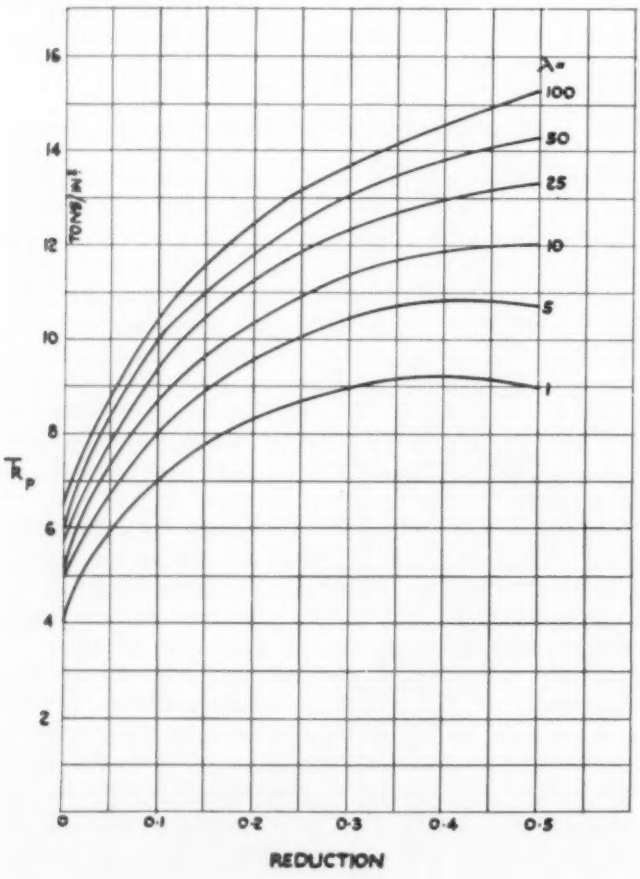


Figure 1 — Curve gives mean yield stress in gross tons per sq in. to produce unit strain at various strain rates for 0.17 per cent carbon steel at 2012 F. λ is a reciprocal of the time in seconds.

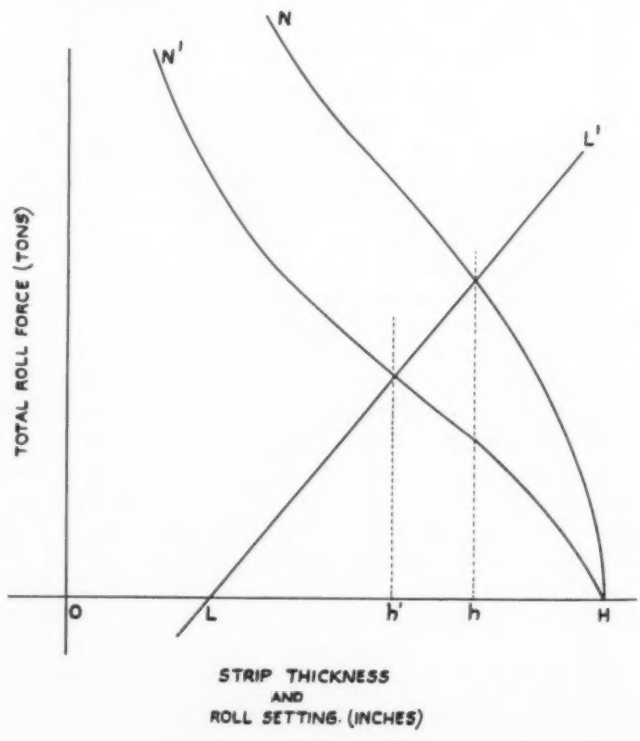
Figure 2 — Curve gives mean yield stress in gross tons per sq in. to produce unit strain at various strain rates for 0.17 per cent carbon steel at 1832 F. λ is a reciprocal of the time in seconds.



although changes in mill speed will affect gage to some extent by varying the strain rate, and therefore the yield stress of the material in the roll gap.

Of the possible causes of off-gage only three will be considered here; those due to the strip temperature, the strain rate and the applied strip tensions, since it will be assumed that the screw settings are not altered during the rolling of a slab. Temperature and strain rate both influence the gage of strip through their effect on the yield stress of the material. The average, or mean, yield stress[5] (gross tons per sq in.) $(\bar{k})$ vs unit reduction (r) curves for mild steel at 1100 C and 1000 C (2012 and 1832 F), are shown in Figures 1 and 2 for various mean strain rates (λ the reciprocal of time in sec), and the quantitative effect of changes in yield stress on gage is shown diagramatically on the F/h diagram[8] of Figure 3. Here the line L L′ is the elastic equation to the mill, or mill spring, and OL represents the roll setting before the strip enters the rolls. The distance OH is proportional to the entry thickness and the lines HN and HN′ represent the roll force vs rolled strip thickness curves (or plastic equations) of two slabs which are similar in every way except the temperature of that represented by HN is lower than that represented by HN′. The intersection of the elastic and plastic equations gives the rolled strip thickness, and the material with the lower yield stress (or higher temperature) is rolled to the thinner gage h′. A study of the yield stress-reduction curves of Figures 1 and 2 will show that of the two variables affecting the yield stress at a given reduction, temperature is the more important. Indeed, in a mill with rolls rotating at constant speed, strain rate can vary only with changes in entry thickness and reduction. Hence from the assumption that the mill has constant roll settings, the effects of changes in strain rate on a given slab may be neglected.

Figure 3 — Diagram shows effect of changes in yield stress on product gage.



The effect of tension on load, torque and strip gage in cold rolling has been described in detail by Hessenberg and Sims,[6] and Sims,[8] and its effect in hot mills is similar. An increase in strip tension will reduce the thickness of the strip leaving the stand, providing there is no compensating interaction between the stands,[1] and a reduction in tension will increase the strip thickness. During the rolling of a slab to a coil of strip, it is possible to apply interstand tension only in the finishing mill, and the operator attempts to keep interstand tension as small as possible. It is difficult to see how tensions can, in practice, be held to small values throughout the rolling of each coil in a mill where the interstand looping gear is not used, and in any case some interstand tension is inevitable even when the loopers are in operation, and the loss of tension as the end of the strip leaves each stand in the mill train must give rise to gage changes.[9]

These factors affecting strip gage will now be examined in detail.

The rate of cooling of an infinite plate of finite thickness—At the temperature at which steel is hot rolled, loss of heat by convection may be neglected in any approximate calculation and the material may be supposed to lose heat by radiation only. A general solution to this problem is given in an appendix, but a simple expression may be derived which is useful in describing the heat losses in a qualitative fashion. Since the width and length of the material in a hot mill are always much greater than the thickness, the heat flow will be normal to the surface, and if it is assumed that the thermal gradient in the material is small then:

$$Ahc\rho\Delta\theta_s = 2\epsilon\sigma A\ (\theta_s^4 - \theta_A)\Delta t \quad \ldots\ldots\ldots (1)$$

where

A = area of a small element on the surface (cm^2)
t = time (sec)
h = thickness of the material (cm)
ϵ = emissivity of surface (assumed to be 0.8 for hot rolled material)
θ_s = surface temperature of the material (deg K) at time t.
θ_A = temperature of surrounding space (deg K) i.e., the ambient temperature
c = specific heat (gm-cal per gm per deg C) = 0.1530 for steel at 1100–1000 C
ρ = density of material (=7.87 gm per cu cm)
σ = the Stefan-Boltzmann constant (cal per sq cm per sec per deg K^4) = 1.36×10^{-12}

The cooling rate for unit thickness is then:

$$\frac{1}{h}\frac{dt}{d\theta_s} = \frac{c\rho}{2\sigma\epsilon(\theta_s^4 - \theta_A^4)} \quad \ldots\ldots\ldots (2)$$

and this becomes

$$\frac{\Delta t}{h} = \frac{5.52 \times 10^{12}}{\theta_s^4 - \theta_A^4} = \text{sec per cm for each 10 C change in temperature at about 1100 C.}$$

The mechanism of gage rundown due to temperature—The majority of wide strip mills have front discharging furnaces, so that, as the bar leaves the final roughing stand for the delay table, the thermal history of two arbitrarily chosen small areas of surface, one at the front and the other at the rear will differ by the time taken for the rear element to reach the rolls of each stand in comparison with the leading element, and during this time it will cool differentially. Since the slab length in the majority of existing wide strip mills is usually 18 ft (5.5 m) long, and the entry speed of the slab at the first rougher is usually about 120 fpm (6.2 m per sec), this differential cooling time is of the order of nine seconds at the first roughing stand. In this time the rear element of a 7-in. (178 mm) thick slab has cooled four to five degrees C only in comparison with that of the leading end. Similar small changes occur at each of the early roughing stands.

TABLE I
Values of $\Delta t/h$ for Slab Initially at 1100 C

Temperature C	$\Delta t/h$ Sec per cm at 10 C intervals	$1/h\ \Sigma\Delta t$ Sec per cm at 10 C intervals
1100	1.6	0
1090	1.6	1.6
1080	1.7	3.2
1070	1.7	4.8
1060	1.8	6.5
1050	1.8	8.3
1040	1.9	10.1
1030	1.9	12.0
1020	2.0	13.9
1010	2.0	15.9
1000	2.1	17.9
990	2.2	20.0
980	2.3	22.2
970	...	24.5

A usual rolling speed for the fourth roughing stand of a wide, continuous strip mill is 400 fpm (2.05 m per sec) and for the first finishing stand a figure of about 325 fpm (1.7 m per sec) is appropriate when rolling to finishing gages below 0.100 in. Assuming that the first finishing stand takes a 45 per cent reduction on a bar 0.9 in. thick (22.8 mm), and that the forward slip is negligible, the entry speed of the material is therefore 179 fpm (0.9 m per sec). This will produce 0.080 in. (2.00 mm) thick material out of stand 6 at about 2000 fpm (10.2 m per sec), and this is about the maximum speed at which this gage can be taken down to the coiler. The time spent by the bar on the delay table while stationary will, to a first approximation, affect all elements of the bar equally, and may be neglected in these calculations, together with the acceleration and deceleration times. If the bar is 140 ft (43 m) long and the free length of the delay table is 180 ft (55 m), the front element of the breakdown will take about 27 sec to reach a position immediately in front of the first finisher where it will come to rest. The rear element will be on the delay table for six sec before it stops. When the bar is moved into the first stand it will take the rear element an additional 47 sec before it enters the finishing train. The total time in motion on the table of the front element is, therefore, 27 sec while the rear element is moving during a total 53 sec on the table.

Assuming a breakdown of 0.9 in. (2.28 cm) thick, and that it leaves the final roughing stand at 1100 C the front end will cool to 1030 C before it enters the first finisher, while the rear element will cool to 975 C, a difference between front and back ends of 55 C or 99 F.

The above calculations suppose that the slab is 7 in.

TABLE II

Width, in.	Nominal gage, in.	Material	Measured gage, in.					
			Front			Back		
			Left	Middle	Right	Left	Middle	Right
17 9/16	0.206	Mild steel	0.207	0.209	0.207	0.207	0.209	0.207
17 9/16	0.206	Mild steel	0.206	0.208	0.206	0.206	0.208	0.206
17 9/16	0.206	Mild steel	0.208	0.210	0.208	0.208	0.210	0.208
9 5/8	0.133	Mild steel	0.134	0.135	0.134	0.134	0.135	0.134
9 5/8	0.133	Mild steel	0.135	0.136	0.135	0.135	0.136	0.135
9 5/8	0.133	Mild steel	0.136	0.137	0.136	0.136	0.137	0.136

(178 mm) thick. With a 5-in. (127 mm) thick slab, rolled to 0.9 in. (2.28 mm) at the delay table the bar would be 100 ft (31 m) long. The front end would take 27 sec to travel down to the first finisher and the rear end would be on the table 12 sec before it came to rest, and spend a total of 46 sec on the table before it entered the first finishing stand. The front end would cool to 1030 C as before, the rear end to 988 C a differential of 42 C. These calculations are made on the basis of the simple equation given above. Using the more exact analysis in the appendix, which does not assume uniform transverse temperature in the slab, the differential cooling becomes 51 C for the 7-in. (178 mm) slab with an average temperature at the center of 25 C above the surface temperature; while for the 5-in. (127 mm) slab rolled to 0.9 in. (2.28 mm) thick leaving at the roughing stand at an average temperature of 1100 C the differential would be 37 C. It should be realized that the calculations will be in error; (a) due to the fact that the underside of the bar may radiate to space appreciably higher in temperature than that into which the top surface radiates, and so may cool more slowly; (b) descaling water, at the first finisher may cool the rear end to a greater extent than the front end, and (c) and most important of all, the insulant effect of scale formed on the bar will also interfere progressively with the free loss of heat from the material, and give errors in any measurements made with a surface pyrometer, in proportion to the time the surface is fully exposed to air, so that the figures quoted above will be progressively in error as the length of bar on the delay table increases, other conditions being equal.

In one mill, where records are available, the leading ends of bars 25 in. wide, 0.850 in. thick, were on the table for an average of 12 sec and the trailing end 80 sec. The measured cooling was 160 F. At the last finishing stand the measured difference was 85 F, the difference in the two sets of readings being due in part at least, to measuring errors due to scale on the bar on the delay table.

There is another type of hot rolling mill in common use for rolling narrow material where this differential cooling does not take place. These mills have the roughing stands and the finishing stands grouped together and usually separated by a small delay table, although mills have been designed with a long delay table. In these mills the roughers are synchronized with the finishers so that the bar leaves the last rougher at the speed it will enter the finishers. No temperature gradient will therefore exist in the strip, and provided interstand tensions are not exerted, the material should be rolled to uniform gage. Table II gives a series of readings taken from such a mill.[12] It will be seen that the hypothesis, that the difference in speed between the last rougher and the first finisher causes off gage, is amply supported.

A medium width mill has been built on these principles, and the results from it confirm adequately the theory. The close-coupled roughing mills are separated by a long delay table from the six finishing stands. If the roughers are not synchronized with the finishers, and the loopers are not used so that interstand tensions are high, a typical coil profile would show a decrease of 0.005 in. (0.125 mm) in thickness at the leading end, and 0.011 in. (0.275 mm) at the trailing end. This pattern becomes a leading end decrease followed by an equal trailing end increase in gage when the roughing speeds are synchronized with the finishers but without the loopers in use. The mill will roll uniformly to gage to within ±0.001 in. (0.025 mm) except where cool spots exist on the bar due to skid marking in the furnace, when the looper gear is employed to keep interstand tensions to a low and controlled value.

The mechanism of gage changes due to applied strip tensions—The general effect of the applied strip tensions on the rolled strip thickness has been described above, and it is of interest to discuss the effect quantitatively. The equations to the roll force and torque developed in hot rolling have been derived by Sims.[5]

The equations to the roll force and torque developed in hot rolling (see Appendix I for notation) have been derived by Sims[5] who solved Orowan's[11] equations:

$$T_\psi = z_f(\psi)\left[\int_0^\psi \frac{B_f(\psi)}{z_f(\psi)}\,d\psi - T_f\right]$$

$$T_\psi = z_b(\psi)\left[\int_\phi^\alpha \frac{B_b(\psi)}{z_b(\psi)}\,d\psi - T_b\right]$$

for the case where T_f and T_b, the applied strip tension forces, are simultaneously zero and derived an equation to the specific roll force P_0 in the form

$$P_0 = \sqrt{R'\Delta H}\,\bar{k}_p Q_p \qquad (3)$$

where Q_p is the dimensionless number which gives a measure of the frictional forces involved and also of the nonhomogeneous nature of the deformation. The equation has now been solved when tensions are applied to the strip, and the solution is in the form

$$P = P_0 - \sqrt{R'\Delta H}[(1 - \phi/\alpha)\,t_b + (\phi/\alpha)t_f] \qquad (4)$$

where t_f and t_b are the applied front and back tension stresses, ϕ is the neutral angle and α is the angle of strip entry. The detailed analysis and terminology is given in Appendix I.

The effects of changes in tension on the thickness of strip rolled in a hot mill are quite large, and may be

calculated using an F/h diagram and equations (3) and (4) above. In a conventional medium width hot strip mill an interstand tension of 25,000 lb between the fourth and fifth finishing stands is not unusual, and the sudden removal of tension, for example when the end of the strip leaves the fourth stand, will produce a change in gage of 0.0018 in. at the fifth stand.

The application of large interstand tensions is a complicating factor from the viewpoint of the design of automatic gage control equipment since it ties a controlled stand to the adjacent stands of the mill train. If a screwdown system of automatic gage control is installed on stand 2 of a finishing mill, and the rolls are adjusted to correct for an incoming increase in strip thickness, the speed of the incoming strip will be reduced and there will be a much smaller change in the exit speed also. If, at the same time, the strip is being rolled under considerable tension, these changes in speed at stand 2 will be communicated backward to stand 1 and, to a lesser extent, to stand 3. For this reason some forms of automatic gage control on hot mills have been projected with elaborate subsidiary programmed controllers in addition to the main automatic gage control, in order to keep the strip in equilibrium in the mill.

A relatively simple way of avoiding the application of excessive tension to strip, and at the same time isolating a control stand from adjacent mills, is to fit a well designed set of looper rollers and roll with them elevated above the passline. It is a matter of observation, however, that the majority of strip mills roll without the looper gear in operation, and with the strip under some indeterminate tension between the stands. The reason for such practice is not clear. One explanation which is sometimes advanced, is that the droop in the mill drive as the strip is entered can cause an excessive loop to form very quickly and cause a wreck if a multi-layer lap should enter the roll bite. Another suggestion is that existing loopers cannot be raised quickly enough. Individual stands are adjusted by hand therefore to prevent any loop forming, and the aim is to roll with only a small interstand tension. The mill operators attempt to adjust the stand speeds so that a certain amount of vertical flap can be seen as the material passes from one stand to the next. The weakness of this technique can be seen by examining the conditions of rolling toward the end of a coil, and by measuring the actual gage after rolling. On the other hand effective automatic looper controls have been used for years on narrow mills in Europe and have proved that, when properly designed, loopers are a useful means of reducing strip tensions.

The requirements for a successful looper design are:

1. It should have a fast response time, so that the looper roller between stand N and stand (N + 1) can be raised immediately the material has been threaded from stand N into stand (N + 1) and lowered just before the trailing end leaves stand N.

2. The control of the loopers should be automatic, and controlled either from a loadmeter or from the armature current in the mill motors.

3. The design of the looper should be such that it can store a reasonable amount of strip between the stands at a tension which is constant to within ±10 per cent.

This last requirement is of importance. Many looper

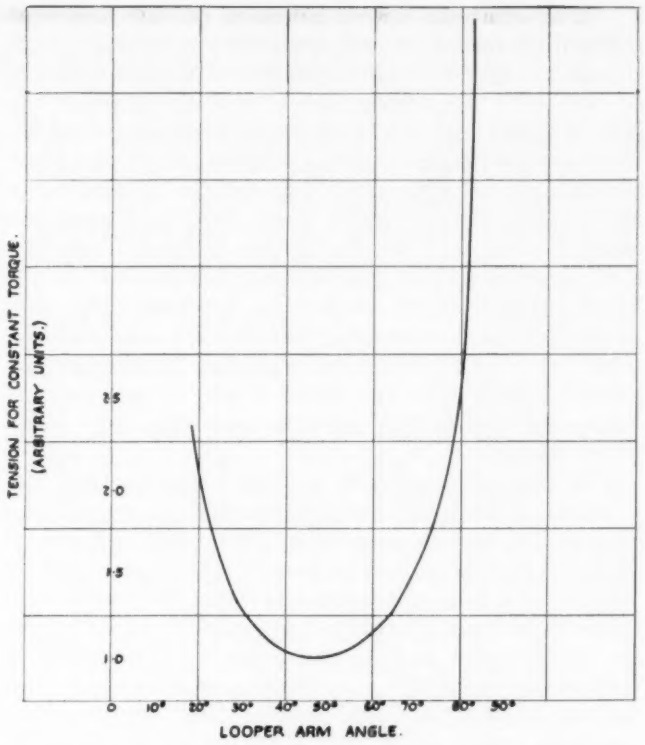


Figure 4 — Curve shows variation in temperature with changes in looper angle.

rollers are driven at present by torque motors via a large reduction gearbox, frequently a wormgear so that it is slow to operate and will not rise and fall efficiently with the strip. Moreover these simple looper rollers will not maintain even approximately constant tension. Figure 4 shows variation of strip tension with changes in attitude of the arm and roller of a typical set of looper gear on a modern strip mill. About eight in. of strip is stored in the loop to be paid out (or taken in) when the speeds of the two stands change relatively to each other, but in doing so the interstand tension applied to the strip changes very considerably.

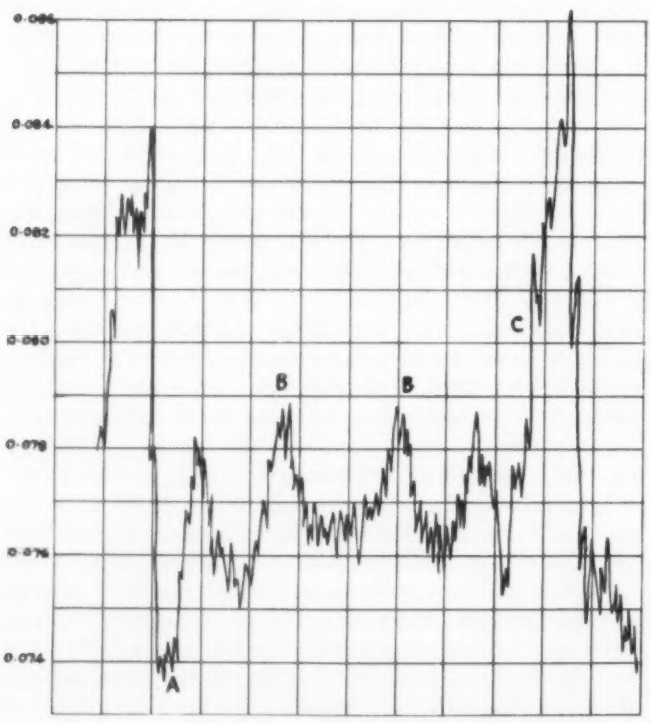
It has already been shown that the material at the end of a bar enters the first stand of the finishing mill at a lower temperature than the leading end. This drop in temperature brings an increase in the yield strength of the material, and as a result the roll loads and torques in the stands increase. The increase in roll force causes an increase in gage and tends to change the speed ratios between the stands; the extra torque loads the mill motors which tend to slow down. Unless the strip is rolled with the looper rollers up, the speed changes are reflected as increases in strip tension. This will tend to compensate to some extent for the increase in strip gage due to roll load changes; but as the end of the bar leaves each stand the release in interstand tension built up between each stand due to the temperature changes will give rise to sudden increases in strip thickness, in a pattern all too familiar both to hot and cold mill operators. If, on the other hand, an efficient looper gear had been used, the changes in temperature and the resultant change in stand speeds would have caused negligible tension changes; and while the slow change in gage along the length of the bar would have been more pronounced, there would on the other hand have been little change in gage as the tail end dropped out of the stands of the finishing train.

The analysis above is based on the assumption that the mill operators are sufficiently attentive throughout the shift to keep the stand speeds in careful adjustment, so that with the loopers out of use, the start of the strip is rolled with relatively small interstand tensions. It requires little experience in mills to realize that these conditions are rarely met. Without the movement of the looper rollers to guide them, the stand operators rarely compensate for the minute-to-minute changes that occur, and their grosser errors are reflected in the width changes which occur in the product. Only a few minutes spent in examining records from a widthmeter sited over the runout table will show how large and arbitrary these tension induced width changes may become, and they do not make the subsequent processing of the coil easier.

The effect of tension on gage for a hypothetical case of strip rolled in a mill under appreciable interstand tension has been made the subject of a computer study by Phillips[9] and the use of tension has been proposed by Ringger and Koss as a control medium.[13] It would seem from the foregoing analysis that much is to be gained by rolling under as low, and as constant a tension as possible, by using the looper rollers at least in the first five stands of a six stand finishing mill. The improvements to stand drives needed to maintain control of strip tensions, and ensure a smooth entry of the piece has already been outlined by Ringger.[10] From the point of view of designing automatic gage control equipment, the use of loopers and a low controlled tension would have the immense advantage of isolating the mill stands.

Figure 5 shows a recording of gage from a hot strip mill rolling a tinplate order 0.072 in. thick. The decrease in thickness at point A at the head of the coil is due to the application of tensions as the material enters the stands. The body of the coil is of reasonably constant thickness except where the slab has been unevenly heated in the reheating furnaces (points B) and the pattern of the furnace skids are apparent, and then at the end of the coil, point C, there is the rapid increase in thickness as the end of the coil leaves the stands, and tensions are released.

Figure 5 — Effect of tension on gage is graphically illustrated by curve.



SEMI-CONTINUOUS MILL

The analysis given above for the variation of temperature changes in a bar on a delay table applies only to the continuous mill equipped with four or five roughers, each taking a single pass on a slab. Hot mills are frequently built with a reversing rougher, in order to save on the initial capital expenditure in laying down a hot strip mill. The temperature changes are greater in this layout. A semi-continuous mill with a reversing rougher and six finishing stands is capable of an output of over 1,300,000 tons a year, but the semi-continuous mill having the smallest first cost would probably employ a reversing rougher and four finishing stands. A three-stand finisher would tend to give unacceptably small coils for a given gage tolerance, as will be shown below. The reversing rougher must give rise to a temperature differential along the breakdown before it enters the finishing stands. If the two ends of the slab are designated A and B, with end B entering the rougher first, then B would issue from the stand at the rolling speed and would cool at a rate appropriate to the new thickness while A would enter the stand at a slower speed, and cool at a rate proportional to the original slab thickness. In the second pass A would issue at the rolling speed of the mill at the finishing thickness of the pass and cool accordingly, while B would continue to cool at constant thickness as it approached the mill for the second reduction. Not only does this roughing process induce non-uniform cooling along the breakdown because of this non-symmetrical thickness distribution, but the temperature variation is increased in practice by the fact that the rolling speed is increased in later passes from a speed of about 300 fpm (1.53 m per sec) at the first pass to about 700 to 1000 fpm (3.6 to 5.1 m per sec) on the last pass.

For the roughing stand of a semi-continuous mill the minimum speed for the last pass would be about 700 fpm (3.57 m per sec) and the upper limiting speed for entering the first stand of the finisher is about 300 fpm (1.53 m per sec). The breakdown on a reversing rougher, 3-stand finisher would be about 0.3 in. (0.76 cm) when producing 0.072 in. (1.80 mm) finished strip, so that, with a 3-in. (75 mm) slab 12 ft (3.7 m) long, the breakdown will be 120 ft (37 m) in length rolled in five passes, and would represent a coil weight of 120 lb per in. (2.2 kg per mm) which is very close to the practical minimum. The finishing speed would then be 1250 fpm (6.1 m per sec). A calculated cooling rate up to the time of entering the first finisher is shown in Table III.

Additional finishing stands will enable a thicker breakdown to be rolled so that cooling on the delay table is reduced. On the other hand since the final rolling speed on wide strip is limited to about 2000 fpm (10.2 m per sec) for operational reasons, a point will be reached when the thicker breakdown will be associated with a slower entry speed which will in turn increase the temperature differential along the breakdown. Any

TABLE III

Cooling of a Slab Rolled in a Reversing Roughing Mill, up to the Time of Entry into the First Finishing Mill

Pass	L, ft	l, ft	H		h		r, %	V, fpm	v, fpm	t, sec	θ_{A1}, C	θ_{A2}, C	$\Delta\theta_A$, C	θ_{B1}, C	θ_{B2}, C	$\Delta\theta_B$, C	$\Delta\theta_A - \Delta\theta_B$ C
			in.	cm	in.	cm											
1	12.0	22.5	3.0	7.620	1.6	4.064	46.47	160	300	4.50	1200.0	1195.1	−4.9	1200.0	1190.9	−9.1	+4.2
2	22.5	40.0	1.6	4.064	0.9	2.286	43.75	225	400	6.00	1195.1	1174.0	−21.1	1190.9	1179.0	−11.9	−9.2
3	40.0	60.0	0.9	2.286	0.6	1.524	33.33	333	500	7.20	1174.0	1149.9	−24.1	1179.0	1143.0	−36.0	+11.9
4	60.0	90.0	0.6	1.524	0.4	1.016	33.33	467	700	7.71	1149.9	1097.0	−52.9	1143.0	1107.6	−35.4	−17.5
5	90.0	120.0	0.4	1.016	0.3	0.762	25.00	525	700	10.29	1097.0	1036.5	−60.5	1107.6	1026.9	−80.7	+20.2
Entry to finisher	120.0	...	0.3	0.762	...	...	...	300	...	24.00	1036.5	903.9	−132.6	1026.9	1026.9	0	−123.0

L = initial length of bar.
l = final length of bar.
H = initial thickness of bar.
h = final thickness of bar.
V = ingoing speed of bar.
v = finishing speed of bar.
θ_{A1} = temperature at end A before pass.
θ_{A2} = temperature at end A after pass.
θ_{B1} = temperature at end B before pass.
θ_{B2} = temperature at end B after pass.

attempt to roll a larger slab will also increase the differential. The difficulty will always remain, however, that to maintain an economic production, the reversing rougher must be operated at a speed of between 700 to 800 fpm (3.6 to 4.1 m per sec) in its final pass. This is the main problem when dealing with off gage in the semi-continuous mill and additional finishing stands over and above the minimum will at some point decrease the entry speed, and may put an upper limit on the breakdown length and hence coil weight, when these parameters are considered in relation to the acceptable upper limit of gage variations, unless automatic gage control is designed into the mill as a basic requirement of the layout. One way of reducing the differential cooling in a mill would be to lengthen the delay table and construct a holding furnace over it slightly longer than the longest bar to be rolled. If the furnace is heated to 950 to 1000 C (1742 to 1832 F), alloy steel rolls may be used and it would not increase the maintenance of the mill unduly. The temperature control of the strip could be made in the penultimate pass on the rougher. While perhaps unsuitable for a high production mill, this layout on the other hand, would enable low output mills to be built with the minimum of finishing stands, and thereby fulfill a need for a semi-continuous mill with an output of the order of 300,000 tons per year at the least capital outlay.

The fact that the temperature changes are larger in a semi-continuous strip mill than in a continuous mill makes the use of looper rollers even more necessary

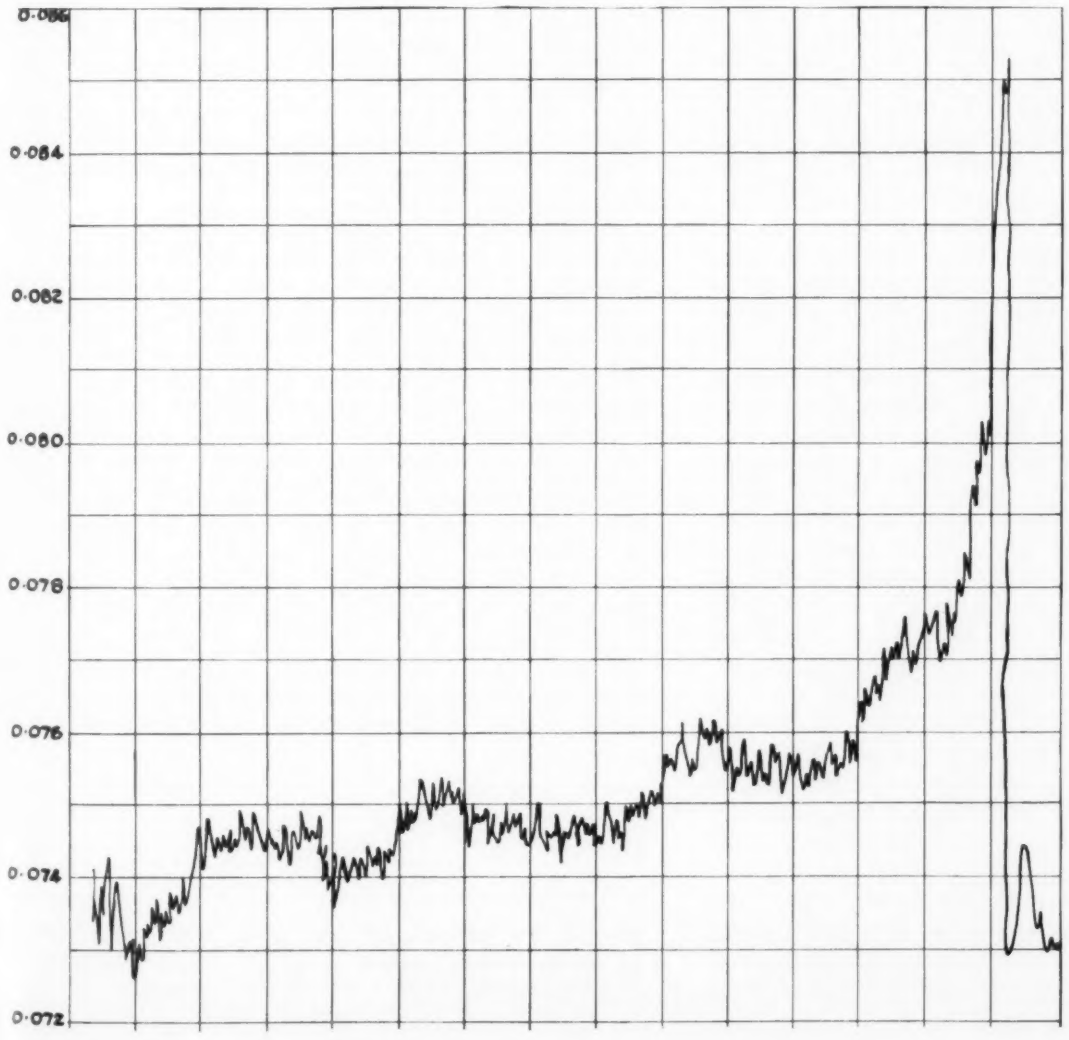


Figure 6 — Typical gage pattern in mill with reversing rougher and six finishing stands.

since the droop in the mill motors in the finishing train will be greater. Many such mills, however, are operated without loopers and their recorded errors on thinner gages is between 0.010 to 0.015 in. (0.25 to 0.37 mm) with much of the change occurring in the last 100 ft of the coil. Figure 6 shows a typical gage pattern in a mill with a reversing rougher and six finishing stands.

THE PLATE MILL

The order of magnitude of the temperature variations in a plate mill may be judged from Table III, if the last line of the calculation, referring to the passage of the breakdown from the rougher to the finishers is neglected. It will be seen that the temperature difference between the ends of the plate will vary cyclically, the thicker end being at the higher temperature. The magnitude of the temperature difference will depend on: (a) the relative difference in thickness (or draft in the pass), (b) the speed of rolling and (c) the length of the plate. Smaller drafts will reduce the temperature differential, a slower rolling speed and a larger plate length will increase the differential, and with it the gage variation.

THE HOT REVERSING MILL

The temperature characteristics of the hot reversing mill are much more complex than those of the mills discussed above. The mill is essentially a simple reversing mill with heated coilers. The material is coiled when it is below about 0.5 in. (12 mm) thick, on to high alloy steel drums at about 950 to 1000 C (1742 to 1832 F), held in furnaces. The end of the coil which is in contact with the drum looses or receives heat from it by conduction depending on whether the material is at a higher or lower temperature than the drum. This can, however, affect only the first three or four laps of the coil excepting only the edges of the coil which can be heated above the temperature of the body of the coil. The remainder of the coil, with the exception of the trailing end which does not enter the coiler, is prevented from cooling by the presence of the adjacent laps, and the cooling in the outer layer of the coil is restricted by the incandescent surface of the furnace, whose main task clearly is to prevent the edges of the coil from cooling with respect to the middle. An appreciable length of material, however, does not enter the coiler, since the end strip must be held by the pinch rolls which feeds it forward into the mill rolls for the next pass. This exposed end, amounting to between 14 and 22 ft (4 to 7 m), cools rapidly during the time the mill is decelerated and reversed for the next pass. It is doubtful whether much of this lost heat is recovered in the following pass when the cool end is in contact with the coiler mandrel. The effect is, of course, cumulative, from pass to pass—15 ft (4.6 m) of strip at 0.5 in. thick left to cool out of the furnace on completing the first pass becomes 75 ft (23 m) of strip at 0.1 in. (2.5 mm) thick at the final pass, and at each succeeding pass 14 to 22 ft (4.7 m) of the cool end is exposed and increases the temperature differential. Moreover, heavy and variable tensions are imposed on the strip, particularly during speed changes. It is not surprising therefore, that the hot reversing mill produces a good deal of off-gage material.

The temperature gradient at the ends of the coil in a hot reversing mill is increased: (a) by the increasing number of passes; (b) by rolling to thin gages; (c) by increasing the length of material exposed at each pass reversal either by increasing the coiler furnace/pinch roll length, or by leaving too great a strip length between the pinch rolls and the mill when it is brought to rest; and (d) decelerating and accelerating the mill slowly. On the other hand the gage control problem is simpler than in a semi- or fully continuous mill since only one stand is involved, with problems similar to those of a cold reversing mill with inferior tension control. It should therefore, be possible to roll material in a hot reversing mill to close tolerances when it is fitted with automatic gage control, but for the reduction of mild steel, the mill will never be a rival to the continuous mill when surface and metallurgical properties are at a premium.

DESIGN OF AUTOMATIC GAGE CONTROLLERS IN HOT MILLS

It is now possible to consider in detail the design of a strip mill to roll to close tolerances in gage. The simplest way is to eliminate completely the causes of off gage from the mill so that a control scheme would not be needed. This, of course, is possible by building the roughing stands with d-c drives and adjusting mill speeds so that the exit speed of the last roughing stand is equal to that of the ingoing speed of the finishing mill. The finishing mill should be fitted with efficient looper gear which should be used on every coil. Many narrow strip mills are built to this design, with the roughing stands close together to conserve building space, although this feature is not necessary. A second, compromise solution would be to build a holding furnace of suitable design over the delay table.

In designing an automatic gage controller for a wide strip mill of conventional design, two fundamentally important decisions must be taken before the control circuit can be considered, one of these is whether the mill is to be operated with the loopers up (i.e., the interstand tensions are low and controlled) or not. If interstand tensions are high and uncontrolled, the strip will be rolled to relatively close tolerances while the material is in all stands of the finishing train simultaneously unless the soaking zones in the slab furnaces are inadequate and the slabs have areas of lower temperature at the furnace skids. However, marked gage discontinuities, due to changes in tension will occur as the front end of the material is entering the stands, and as the trailing end leaves each mill. Moreover the strip material forms an interconnecting link from stand to stand and changes in any one stand will affect the rolling characteristics of the others by way of changes in the strip tension.

The other decision which affects the controller design is whether strip tension is to be used for control purposes. Ringger[13] has shown that quite large tension forces may be applied to the hot strip in the final stands of a continuous mill without unacceptable changes occurring in its width. On the other hand, strip tension as a controlling variable is capable of producing strip to close tolerances since the closed loop controller has a faster response than the screwdown system. The

TABLE IV

Method	Stand 1		Stand 2		Stand 3		Stand 4		Stand 5		Stand 6
1	P	T	AGC(S)	T	P	T	AGC(T)	T_c	O	T_c	O
	V_r		V_r		V_r		V_r		V_c		V_c
2	O	L	AGC(S)	L	O	L	O	L	AGC (S and T)	T_c	O
	V_r		V_r		V_r		V_r		V_r		V_c
3	AGC S	T	AGC S	T	AGC S	T	AGC S	T	AGC (S and T)	T_c	O
	V_r		V_r		V_r		V_r		V_r		V_c

AGC(S) = Gagemeter* controller, screwdown control only. AGC(T) = Gagemeter controller, tension control only. AGC(S and T) = Gagemeter controller, combined screws and tension. O = No control. L = Loopers used. T = Loopers not used, interstand tension not controlled. T_c = Interstand tension used for control. P = Program controller fitted to screws. V_r = Speed of stand controlled.

* The term gagemeter is given to the method of measuring the thickness of strip in the roll gap, or the departure of the strip thickness from the set value, using a loadmeter and a measure of the screw movement. The technique has been described in various papers[8] and consists essentially of correcting the roll opening for the mill spring due to the rolling load. The method has the great advantage that no measuring equipment is near the hot strip, and there are no inherent measuring delays in the system.

principle of using tension in a hot strip mill is a radical departure from accepted practice, and perhaps not one which mill operators will readily accept.

The material from the roughing mill enters the first stand of the finishing train at a reasonably constant gage, but with a temperature gradient along its length. The successive mill stands will convert this temperature gradient into a gradient of strip thickness. The problem, therefore, is where the controlled stands should be sited for maximum effect. Table IV shows three possible designs of controller, there are many alternatives which may be favored to suit particular operating conditions.

Scheme 1 is intended for use where operators will not use the loopers, and the interstand tensions may be large at all stands. Here the control stand 2 must be isolated from stands 1 and 3 by a program controller which adjusts the screws of the mills (or the mill speeds) as the control stand screws are changed. Since the control effected by stand 2 is necessarily coarse, a greater degree of control is needed later on in the mill, and the gagemeter is installed on stand 4 with tension controlled by it between stands 4 and 5 and stands 5 and 6. This scheme is more elaborate than scheme 2 and not so perfect. The width changes are also greater.

The second scheme is the simplest. Loopers are used to isolate the control stands; screwdown control is used to produce uniform gage at stand 2 and a combined screw and tension system used to give uniform gage from stand 5. The virtue of the combined scheme is that the screws can be used to reset the tension should it reach the upper limiting value. In this way a fine control can be obtained regardless of the magnitude of the error. Stand 6 takes a small reduction always in strip mills and hence this scheme will give excellent control. The width variations will be small since the changes in tension in such a scheme are not great, reliance being placed on the screws to reset the tension which can then be made to operate over a smaller range.

Scheme 3 has control on all five reduction stands, with a final combined system between stands 5 and 6. It also has a very accurate speed control on all six stands. (This feature can also be applied, with advantage to schemes 1 and 2.) If the strip thickness out of stand 1 is very closely controlled, and all subsequent stands are controlled, then as the strip speeds are closely regulated the interstand tensions will not change and there will be minimum width variation. This scheme is the most precise controller of the three, but it is expensive.

A controller similar to that outlined in scheme 1 has been installed on the wide strip mill at the United States Steel Corp. works at Geneva, Utah, and so far as is known it is the first controller on a wide strip mill. The performance is very satisfactory as can be seen from measurements on strip in paper "Automatic Thickness Control—Geneva Works Hot Strip Mill," by L. E. Ringger and G. S. Koss, February, 1960, *Iron and Steel Engineer*.

SUMMARY

Records taken of the gage variations in coils rolled on continuous mills show that there are three major changes; a rapid decrease at the front of the coil followed by a slow increase in thickness along the length of the coil, and finally a rapid increase in the last 100 ft of the material. It has been shown in this paper that the main causes of these gage variations is the differential between the finishing speed of the last roughing stand and the entry speed of the first finisher, which causes a variation in temperature and thence in yield stress along the length of the coil; and variations in the applied strip tension. If the mill is operated with raised looper rollers and at a constant, small interstand tension, the strip is rolled with a steady increase in gage from front to back due to temperature changes but without the rapid gage changes at each end. If, on the other hand, the loopers are not used, rapid changes in gage at the front and back of the coil occur as tension is applied and released from the coil, much of it engendered by the droop of the mill motors.

Confirmation of these observations may be found in the operation of a strip mill, which, with close-coupled roughers and finishers, produce strip with little or no temperature differential from front to back, and which with carefully designed and used loopers are operated with little or no interstand tension. These

mills will produce strip varying by less than ±0.001 in. from end to end on a slab initially 40 ft long and 4 to 5 in. thick comparing favorably with the large changes which occur in a wide mill with only an 18 ft slab. On larger mills, where the close-coupled arrangement is not favored, the strip rundown may be considerably reduced by rolling with low tensions and with the loopers raised. Even more important from the point of view of automatic control, the gage changes occur slowly when the loopers are in use, and each stand is effectively isolated from the next so that the screws of one stand may be adjusted without immediately affecting the operation of adjacent stands.

From the analysis given above, the characteristics of the automatic gage control unit for existing tandem hot mills begin to emerge clearly. The gagemeter type of control should be used because of its speed of response and freedom from wrecking by cobbles of the measuring equipment between the stands. Control will probably be needed on a six-stand finishing mill on stands 2 or 3, and on stands 4 or 5, the latter unit employing tension as well as screws for control. In order to isolate the controlled stands from the adjacent stands, the mill should be operated with the loopers raised. As an extension to the main controller circuit it is necessary to fit accurate speed regulators to each stand which will compensate for motor droop and make it easier to use the looper equipment and to ensure a smooth entry of the material into the rolls.

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APPENDIX I

Orowan[11] has given the following equations to the forces and stresses in the roll gap

$$T_\psi = z_f(\psi)\left[\int_0^\phi \frac{B_f(\psi)}{z_f(\psi)}\,d\psi - T_f\right]$$

and

$$T_\psi = z_b(\psi)\left[\int_\phi^\alpha \frac{B_b(\psi)}{z_b(\psi)}\,d\psi - T_b\right]$$

where

t_b = back tension stress on the material (tons per sq in.)
t_f = forward tension stress on the material (tons per sq in.)
T_ψ = the horizontal force in the roll gap at coordinate ψ (tons)
T_f = forward tension force applied to strip (tons)
T_b = back tension force applied to strip (tons)
s = vertical stress on the material (tons per sq in.)
ψ = angle made by any point on the roll surface with its center of rotation (radians)
R' = deformed roll radius (in.)
y = strip thickness at the point $R' = h + R'\psi^2$ (in.)
k = yield stress of the material (tons per sq in.)
H = strip thickness before deformation (in.)
h = strip thickness after deformation (in.)
α = angle of entry (radians)
ϕ = neutral angle (radians)
$z_f = y/h$
$z_b = y/H$
$B_b = 2R'k[(\pi/4) - (1/2)]$
$B_f = 2R'k[(\pi/4) + (1/2)]$
ΔH = draft (in.) = $(H - h)$

From Orowan's theory of plastic flow in the roll gap for strip rolling[5]

$$T/y = (s - \pi/4k)$$

so that

$$s_f - k\pi/4 = \int_0^\phi \frac{2R'k[(\pi/4) + (1/2)]}{y} - t_f$$

and

$$s_b - k\pi/4 = \int_\phi^\alpha \frac{2R'k[(\pi/4) - (1/2)]}{y} - t_b$$

The rolling load is defined as:

$$P = R'\int_0^\alpha s\,d\psi$$

so that

$$P = R'\left[\int_\phi^\alpha \frac{2R'k[(\pi/4) + (1/2)]}{y}\,d\psi + \int_0^\phi \frac{2R'k[(\pi/4) - (1/2)]}{y}\,d\psi + k\alpha\pi/4 - (\alpha - \phi)t_b - \phi t_f\right]$$

$$= P_0 - \sqrt{R'\Delta H}\,[t_b - (\phi/\alpha)t_b + (\phi/\alpha)t_f]$$

where

P_0 = rolling load under identical geometrical conditions when no tensions are applied to the strip
$= \sqrt{R'\Delta H}k\,Q_p$

and

Q_p = a function defined by Sims[5]

As a first approximation in calculations ϕ/α may be put equal to 0.5 and then:

$$P = P_0 - 1/2\sqrt{R'\Delta H}(t_b + t_f)$$

APPENDIX II

Temperature changes in a slab of material—The following analysis applies essentially to the cooling of a slab or bar of steel while at rest, or moving on the tables of a hot mill. It is assumed that the material is initially at a uniform temperature throughout and its thickness is small compared with its length and width; that the temperature is always greater than about 800 C (1472 F) so that convective heat losses may be neglected; that edge affects may be neglected; that the two large surfaces radiate into a space with uniform characteristics and that in the relatively small temperature ranges considered the thermal properties of the material do not vary. The numerical solutions are the work of Dr. R. G. Siddall of the University of Sheffield.

1. Simple analysis: The equation on rate of cooling of an infinite plate of finite thickness given in text is:

$$\frac{2\sigma\epsilon(\theta_s^4 - \theta_A^4)}{h\rho c} = d\theta/dt \quad \ldots\ldots\ldots\ldots (1)$$

which on integration gives:

$$t = \frac{h\rho c}{8\theta_A^3\sigma\epsilon}\left\{\ln\left[\frac{(\theta_s + \theta_A)(\theta_0 - \theta_A)}{(\theta_s - \theta_A)(\theta_0 + \theta_A)}\right] - 2\tan^{-1}\left[\frac{(\theta_0 - \theta_s)\theta_A}{\theta_s\theta_0 - \theta_A^2}\right]\right.$$

where θ_0, is the surface temperature at $t = 0$, and this solution although admitting a simple solution for the purposes of discussion in the text of the paper, is difficult to handle in a general computation.

The analysis may be simplified by replacing the radiation losses by an approximately linear function, i.e., replacing the term $\sigma\epsilon(\theta_s^4 - \theta_A^4)$ taking

$$\sigma\epsilon(\theta_s^4 - \theta_A^4) \equiv G(\theta_s^4 - \theta_A^4) \quad \ldots\ldots\ldots (2)$$

where

θ_A = a pseudo ambient temperature
G = a pseudo heat transfer coefficient.

Both constants are chosen to give the best possible fit between the linear law and the fourth-power law over the small temperature range involved in the cooling of the slab on the mill. The solution of the cooling curve is:

$$\theta_s = \theta_A' + (\theta_0 - \theta_A')\, e^{-(2H/h\rho c)t} \quad \ldots\ldots\ldots (3)$$

2. The more detailed analysis: The treatment of the problem given above is based on the assumption that the slab remains at a uniform temperature throughout, i.e., θ_0 is a constant through the metal thickness. In practice there will be a temperature gradient from the surface to the center of the slab. The following analysis is given to test the accuracy of the approximate solutions, and allowance is made for conduction within the slab of material with a thermal conductivity and of finite dimensions.

The heat balance within the slab gives the following standard differential equation:

$$d\theta/dt = Dd^2\theta/dx^2 \quad \ldots\ldots\ldots\ldots (5)$$

where

x = the distance from the centre of the slab to the point under consideration, at temperature θ
D = the thermal diffusivity of the slab, i.e., or $K/c\rho$
K = the thermal conductivity

The equation must be solved for the boundary conditions: $d\theta/dx = 0$ when $x = 0$ and $t > 0$; and $\theta = \theta_0$ when $t = 0$, and $-Kd\theta/dx = \sigma\epsilon(\theta^4 - \theta_A^4)$ at $x = h/2$ and $t > 0$.

With these boundary conditions a solution is impossible, but the problem may be reduced to manageable proportions by putting

$$\sigma\epsilon(\theta^4 - \theta_A^4) \equiv G(\theta - \theta_A')$$

as above in equation (3) and then the solution becomes

$$\theta = \theta_A' + (\theta_0 - \theta_A') \times \sum_{n=1}^{\infty} \frac{2L\cos\beta_n\zeta}{(\beta_n^2 + L + L^2)\cos\beta_n} e^{-\beta_n^2 J} \quad \ldots (6)$$

where

ζ = $2x/h$
J = $4D^2t/h^2$
L = $hG/2K$
β_n = the positive roots of the equation $\beta\tan\beta = L$

From equation (6) the important quantities are the surface temperature

$$\theta_s = \theta_A' + (\theta_0 - \theta_A') \sum_{n=1}^{\infty} \frac{2L}{(\beta_n^2 + L + L^2)} e^{-\beta_n^2 J} \quad \ldots (7)$$

and the center temperature θ_c given by

$$\theta_c = \theta_A' + (\theta_0 - \theta_A') \times \sum_{n=1}^{\infty} \frac{2L}{(\beta_n^2 + L + L^2)\cos\beta_n} e^{-\beta_n^2 J} \quad (8)$$

Discussion

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Dr. M. D. Stone: While the matter of controlling strip gage from cold mills has been the object of considerable study, during the past decade, it has only been recently appreciated that the real offender is the hot band, coming off the hot strip mill. Perhaps the first specific paper on this subject was by Phillips[9] in 1957, cited by the author—and certainly since that time, much thinking and designing and mill building has been and is being carried out, with objectives of improving hot strip gage. Messrs. Ringger's and Koss' paper[13] discussing the modifications in the speed control of the finishing mills of the USS-Columbia Geneva hot strip mill, to practice automatic gage control by varying

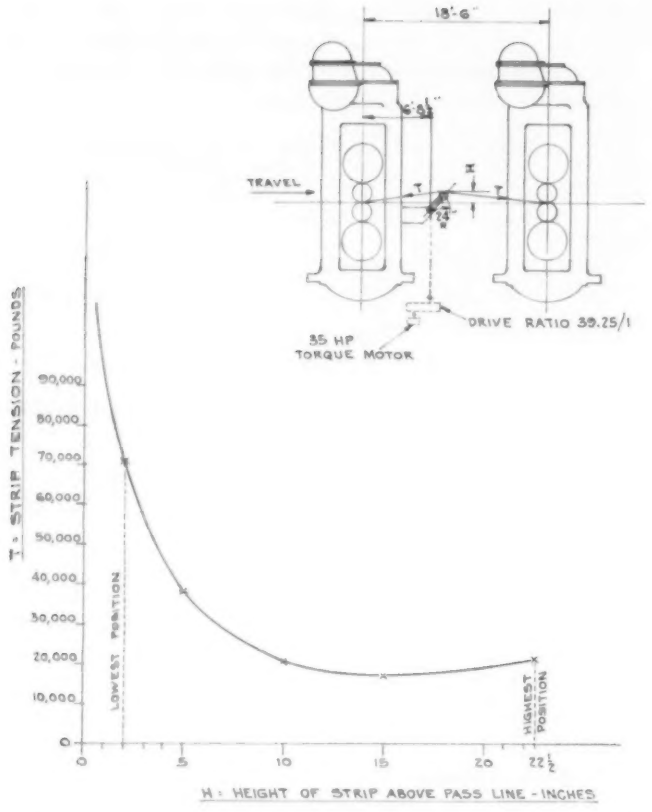


Figure 7 — With a conventional looper, strip tension can vary more than 300 per cent.

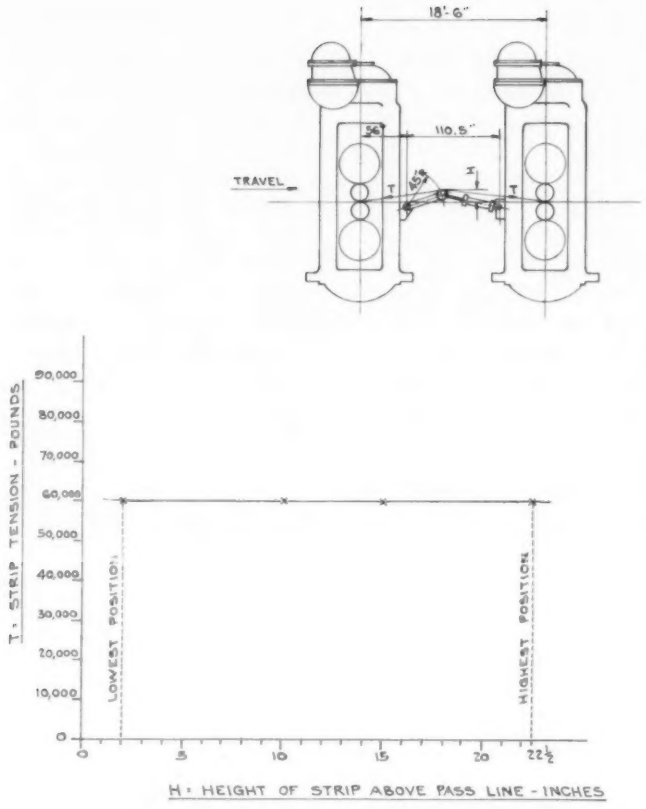


Figure 8 — A new type tensiometer can keep strip tension almost constant.

interstand tensions as well as screw positions, represents the first actual attempt along these lines, as Mr. Sims has mentioned.

The author's current paper carries the literature on this new and important subject very far indeed and we commend Mr. Sims most heartily for his now-to-be-expected highly sound approach. Mr. Sims very rightly goes back into the design arrangements of hot strip mills to put his finger on the primary cause of gage variation—the lack of synchronization of the delivery speed of the last rougher and the entry speed of the first finisher. This is not to discount such other causes as non-uniform heating of the slabs, initial thickness variations in the slabs, etc. But the temperature variations created in the strip as a consequence of the various conventional mill arrangements is the basic cause of hot strip being heavier at the back end, as compared to the front end—by usually around 0.005–0.010 in., but sometimes as much as 0.020 in., when finishing under $\frac{1}{8}$ in. thick. This is also not to forget the rather great gage increases at each end of the strip that everyone is familiar with, and which the author discusses, and which we shall touch on later.

While the writer agrees with Mr. Sims that a fully continuous hot strip mill—i.e., one in which all stands are synchronized, requiring d-c drives throughout, would result in essentially no temperature variation front to back and hence no general gage variation, such a mill arrangement for wide thin strip has other overriding objections. Because, in general, hot strip mills produce $\frac{1}{8}$ to $\frac{1}{16}$ x 48 in. to 80 in. wide strip, the finishing speeds cannot greatly exceed 2000 fpm without courting runout table and coiling difficulties. And because economies dictate 0.8 in. thick starting slabs, entry speeds and general rolling speeds throughout the earlier stands would be so low that excessive strip cooling would result, leading to unacceptable metallurgical properties. In fact one such wide hot strip mill, 38 in. wide, was built along these lines some 30 years ago, and has not been repeated since. For the case of the skelp type mills, cited by Mr. Sims, the finishing gages are heavier, the starting thicknesses less, the finish rolling speeds much higher, and the metallurgical specifications less exacting—so that the gage advantages cited by the author can be gained without the finishing temperatures being too low, etc. We too have considered the possibility of introducing a continuous strip reheating furnace between a synchronized roughing train and finishing train of a fully continuous (although interrupted by an intermediate table) mill as mentioned by the author, but the required furnace length and cost of reheating seem to far outweigh its advantages—so that we find ourselves left with the preferred alternative of developing a superior automatic control system to accomplish the objectives of better gage.

In the early days of hot strip mills, some thirty years ago, when control of mill speeds was quite imperfect, they were designed to operate with loose loops between stands. And the consequent tendencies to "cobble" because of this were largely eliminated by the introduction of motor-operated loopers, which have remained in general use up to the present. Operators learned, however, that generally better strip was obtained by what has been called "speed" operation of the finishing train, i.e., running the strip tight between stands, with the loopers generally maintained in the

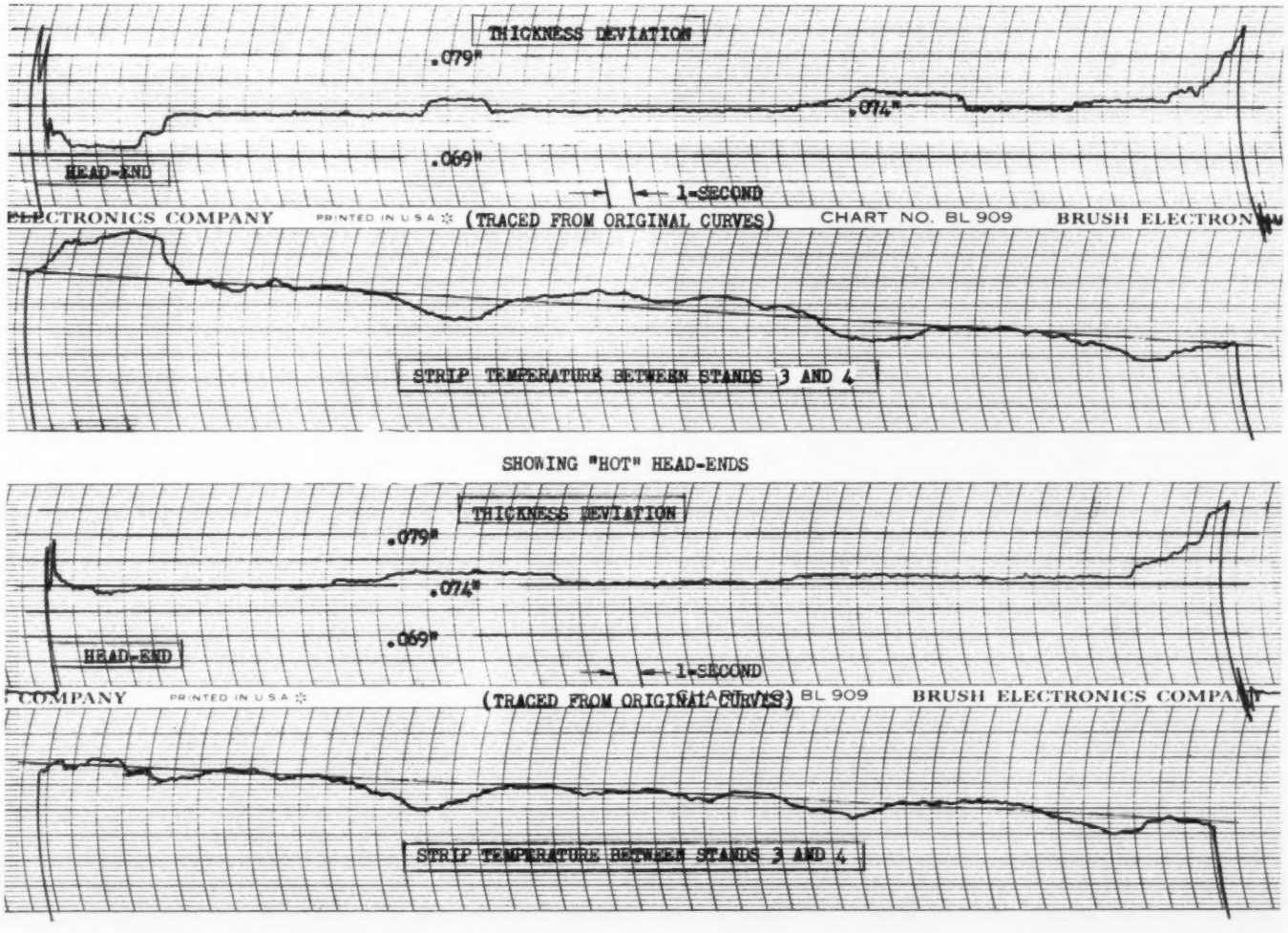
down position. The writer's explanation of this is that gage errors introduced by variations in interstand tension when operated in this manner are less than if the mills are operated with the loopers up—for the present type of loopers. As a result of this conclusion, the writer's company sometime ago developed a new type of hot mill hydraulic tensiometer-looper that eliminates this objection, illustrated in Figures 7 and 8. Figure 7 shows how, for a conventional looper, the strip tension necessarily varies with looper position by more than 300 per cent and is almost the same as the author's Figure 4. In Figure 8 is shown how the strip tension is automatically maintained constant to within 3 per cent by use of the new type tensiometer —which is also inherently many times faster, an important consideration in automatic gage control. The writer could not agree more, therefore, with Mr. Sims on this point, and would mention that such tensiometers are currently being furnished on some six new hot strip mills or mill revamps underway at the present time. In conjunction with the gagemeter type of thickness controller, referred to by the author, these new tensiometer-loopers may be preferably operated to maintain low constant interstand tensions, or to vary interstand tension from a load cell or x-ray signal, or to indicate interstand tension—as desired by the operator. By maintaining low, but adjustable, constant interstand strip tensions, it is expected that the main cause of gage variation—namely, gage increase at the front and back ends of the strip, where rolling is done with no tension as compared to relatively high tension during the rolling of the main body of the coil—will be minimized or eliminated.

L. E. Ringger: Dr. Sims has again contributed to the basic understanding of the phenomena which occur in the rolling of hot-strip. His calculations and observations, for the most part, agree with the experience and data accumulated on the Geneva Works hot-strip mill. Dr. Sims has shown through his examples that many of the problems which mill operators face are inherent in the design of the mill and the selection of mill layout.

The problem which confronted Geneva, and with which operators of other existing hot-strip mills have to cope, is the economical installation of additional equipment to accomplish a desired objective; the decisions to be made for new mill installations are quite different. For example, the loopers of many hot-strip mills are entirely unsuitable for use in a measured tension-control system, and the cost of replacement of the loopers may be excessive when considering an automatic thickness control system. This is only one part of the basic problems which must be resolved for existing mills and may not be a major consideration for a new mill.

The decisions made on equipment modification and

Figure 9 — Curves show relation between the temperature and thickness at the head end of strip when rolling a 0.074 x 34½-in. product. Upper curves show hot head end and lower curves cover controlled head end temperatures.



installation for existing mills will, to a considerable extent, revolve on what is an acceptable thickness profile from head-end to trailing-end of the finished strip. The rapid thickness increase at the extreme trailing-end of the strip which occurs when interstand tensions are increased, or allowed to increase, is not considered as a major problem by many mill operators. The acceptance of a thickness increase at the extreme trailing-end of strip with good thickness performance on the greater part of the strip is one approach to an economical and satisfactory balance of all of the factors which must be considered. This is the approach which was taken for the automatic thickness control system for the Geneva hot-strip mill.

Because, as Dr. Sims states, there are a number of approaches to automatic thickness control, there can be no disagreement with his conclusions and the designs suggested by Table IV. Our experience indicates that a considerable expenditure would be required to obtain the screwdown performance at the estimated operating range required to accomplish the results outlined previous to Table IV. Also, neglecting the effect of tension on the extreme trailing-end of strip, a width gage at the exit side of the finishing stands is an excellent indicator of excessive interstand tension even though the exact location must be detected and corrected manually.

I would like to question Dr. Sims on Figure 5 with reference to the portion of the strip marked "A." This has been explained by Dr. Sims as being due to transient tension as the material enters successive finishing stands.

Our Figure 9 shows a copy of a recording made on the Geneva mill relating temperature to finished thickness. Note the relatively high temperature at the head-end and the corresponding light-gage head-end in upper figure. It has been observed and recorded that most of the Geneva experiences with light-gage head-ends are associated with the speed of the strip through the descaling sprays at the entry-end of the finishing stands; with the speed regulators at Geneva, we find very little, if any, correlation of transient tension to light-gage head-ends. The equipment and operating practice at the entry side of the finishing stands should receive a great deal more attention from engineers and operators. Could the light-gage head-end, shown in Figure 5, be associated with temperature?

T. H. Bloodworth: Efforts to equalize slab temperatures by spray cooling have been ineffective—due to surface cooling only. More significant results have been obtained by zone heating—having the tail end of the slab at a higher temperature than the head end, when it leaves the furnace.

We agree with Dr. Sims on the benefits to be obtained from the use of loopers to regulate interstand tensions. Such automatic controls permit rolling with lower interstand tensions than is possible with manual controls.

The gagemeter control system minimizes off-gage material due to transport time lag. It does not recognize factors such as variations in mill housing and roll temperatures, and in roll wear. Some method of recalibration is necessary to insure satisfactory operation. The gagemeter cannot measure absolute gage unless it is first calibrated to a standard such as an x-ray gage. This calibration is not obtained until the first strip of each schedule will be off-gage—a serious disadvantage when a mill rolls many small orders.

A feedback system, by taking the control signals from measurements of strip thickness, compensates automatically for temperature variations, roll wear, and errors in mill setup.

Compensation for transport time lag is necessary. However, extensive testing on several hot strip mills show thickness variations to be ramp functions, so that effect of transport time lag is small. Rate of thickness variations in most instances is less than 0.001 in. per second in the body of the strip.

Dr. R. B. Sims: Mr. Bloodworth has mentioned the fact that operators have attempted to cool the bar either with sprays, or by heating the ends of the bar differentially in the furnace, but the basic fault with both techniques is that they are a form of programmed control in its crudest form. They seek to control gage in each bar of a series on the basis that the properties and the processing of all bars of a group are identical. A moment's reflection will serve to show the fallacy of such reasoning. If all bars had similar properties, and received similar treatment, then all bars of a single order would be rolled to the same final thickness. This is known not to be true. It follows, therefore, that any attempt to heat or cool bars on a program basis could not be an accurate form of gage control. Similarly, attempts which have been made to screwdown on the trailing end of a bar by programmed control have been unsuccessful in producing close gage tolerances.

Gage controllers, therefore, must be closed loop error-actuated regulators, and two methods are available for deriving the gage error on which the control sequence may be based. Mr. Bloodworth mentions the all important feature of the gagemeter system—that of reducing the transfer time delay, and adds, quite rightly, that the system does not recognize the twin factors of roll wear or change in the mill structure and the rolls with temperature. He is quite wrong, however, in suggesting that the gagemeter system cannot measure absolute gage. It can, and does, more accurately than an x-ray gage. After the second stand in the finishing train, the strip thickness would be of the order of 0.350 to 0.400 in. (8.75 to 10.00 mm) thick so that a fast acting x-ray gage would be in error by at least ±0.005 in. (±0.12 mm) with transient errors of even greater amounts. Experiments have shown that roll wear and roll temperature changes tend to cancel out and as a result the gagemeter drifts by about ±0.002 in. (±0.050 mm) an hour from these causes. The equipment can be rezeroed by pressing the rolls together under a load greater than the critical load (about 300 tons a side for a large mill) when the automatic zero resets the equipment to read absolute gage to an accuracy of about ±0.001 in. (±0.025 mm)—an accuracy unmatched by x-ray equipment in this position. The only persistent error in the gagemeter occurs when the rolls wear heavily concave so that the rezeroing equipment fails to establish accuracy with the rolls touching along their face. This circumstance rarely occurs in well operated mills, where rolls are changed to ensure good tracking and good surface long before this severity of roll wear occurs.

The transport time lag in the first finishing stands of a mill is so long that complex circuitry is essential if

high accuracy control is to be achieved from an x-ray gage, and there is much to be said for the fast acting gagemeter if only because of the essential simplicity and accuracy of its control action and circuitry. Moreover, there is no equipment in the passline where it is so vulnerable to damage from cobbles in a hot mill.

One or two discussers, including Dr. Stone, have touched on the roll problem which would probably arise if a 10-in. thick slab were rolled in a mill with roughers synchronized with the finishers. This may, or may not be true since billet and rod mills are designed with very slow entry speeds and apparently no insuperable roll troubles occur. On the other hand, it would probably be adequate in practice to synchronize only the last two roughers with the finishers when the bar is below 3 in. in thickness to achieve a sufficiently close control of temperature and, therefore, gage.

Mr. Ringger's comments contain, as usual, much sound thinking and he draws attention to a very important cause of thin gage at the leading end of a bar. It will be found that the majority of operators set the scale breaker to turn at the same peripheral speed as the first stand—or even faster—to obtain a smooth entry into the mill, regardless of the fact that with high reductions in the first finishing stand, backward slip causes the bar to move 30 to 40 per cent slower than the rolls. He is therefore quite correct in assigning hot leading ends to this cause and the practice is to be deplored. Nonetheless, if the stand speeds are not set correctly in the first instance, tension will be applied to the bar as it is threaded, and this must also give rise to a thin end. The gage changes in Figure 5 are probably a combination of both causes, just as one suspects, are the rapid changes shown at the leading end of the coil in Figure 9.

Dr. Stone, Mr. Ringger, and Mr. Bloodworth all comment on the controversial subject of the use of loopers in rolling in the finishing stands. Nobody has disagreed with the comment expressed in the paper that until recently looper designs were unsuitable, and for this reason operators no longer use them, and it is encouraging to hear Dr. Stone remark that his company is installing new loopers in several mills. It is appreciated that the financial considerations in re-equipping existing mills with such relatively expensive equipment need careful study, but the savings are so obvious and considerable that they might outweigh the pleadings of the accountants. Once the accountants are convinced, the more difficult problem of converting the operators can be tackled. ▲

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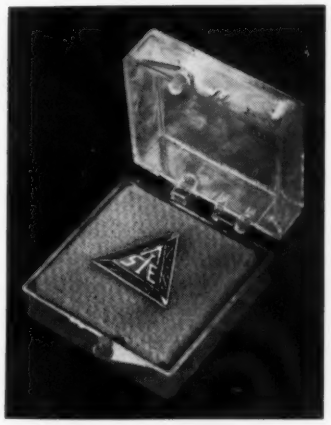

ASSOCIATION OF IRON AND STEEL ENGINEERS

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MICROCHEMISTRY IN LUBRICATING C

by F. M. ROBERTS,
Supervisor, Analytical Dept.,
Texaco Research Center,
The Texas Co.,
Beacon, N. Y.

. . . . microanalytical test procedures have an important place in the modern analyses of petroleum products . . . . in many cases, analyses can be carried out more rapidly and accurately as well as more economically . . . .

MICROANALYSIS is a relatively new branch of chemistry and, like many other scientific developments, was born out of necessity. At the University of Graz, Austria-Hungary, the biochemist Pregl labored for years on gallstone research. Finally in 1910 he reached a crucial stage in his experiments. Before him were a few small crystals whose composition he must determine. Should he spend years accumulating enough samples for a regular analysis or could he devise a new technique which would suffice for the small sample available? He chose the latter course and thus became one of the pioneers in the field of microanalysis.

Industrially, the pharmaceutical companies were first to employ microanalysis since small samples are common in biological work. Much of the work done on vitamins and similar materials isolated from plant and animal products would have been impossible without microchemical techniques.

That the petroleum industry, which measures its yield of product in terms of millions of barrels should have need of microchemical methods, would perhaps seem strange. However, it happened in ever increasing numbers of cases that the petroleum analyst was forced to report "sample too small for analysis." Many of these samples involved very important information and this loss prodded the petroleum industry into an awareness of the value of microanalysis. Today no petroleum laboratory can be considered complete without a well equipped microchemical laboratory.

The basic idea of microanalysis is the reduction in size of analytical apparatus to suit small samples. In some cases, reduction in size alone has sufficed: more often, retention of the original form of the apparatus is unsatisfactory and new principles must be employed. As in macro, that is regular scale analysis, physical properties are determined on the sample as received but chemical analysis usually requires transforming the unknown into one or more known materials. In this latter case it is necessary to carry out chemical reactions, then separate, purify and measure the quantities of materials obtained from the unknown.

The term microanalysis is usually applied to techniques involving sample quantities of 10 milligrams or less. The definition is not strict and a broader interpretation can be used. As a matter of convenience the term is sometimes applied to the analysis of samples that are of too limited a quantity to be analyzed by standard procedures.

The relative quantities involved in making microanalytical measurements are illustrated below:

$$\text{Milligrams} = \frac{\text{gram}}{1000}$$

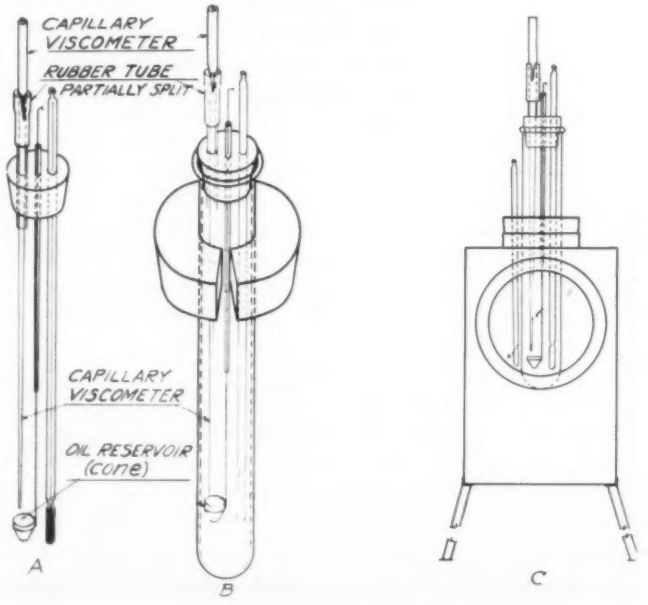
$$\text{Microgram} = \frac{\text{gram}}{1{,}000{,}000}$$

$$\text{Milliliter} = \frac{\text{liter}}{1{,}000}$$

$$\text{Microliter} = \frac{\text{liter}}{1{,}000{,}000}$$

It would not be possible to describe all of the microanalytical techniques used in a petroleum laboratory for

Figure 1 — This apparatus can determine viscosity using only a fraction of a drop of oil.



G OIL ANALYSIS

they number in the hundreds. This paper will consider a few microtechniques which might be applied to a sample of lubricating oil (either used or unused) submitted for analysis.

VISCOSITY

Viscosity is the most important single property of a lubricating oil. Many different methods for microviscosity have been devised. One convenient method is based on the rate of rise of the sample into a vertical capillary.

The micro determination of viscosity using this principle can be applied to a fraction of a drop of oil. A capillary tube (Figure 1) is lowered into the sample which is held in a metal cone reservoir and at the same instant a stopwatch is started. Time for the oil to rise in the capillary to an arbitrarily placed line is measured. The Saybolt Universal viscosity in seconds is obtained by reference to a curve (Figure 2) based on data obtained with samples of known viscosity. The unknown should be compared to a curve for a similar type oil since surface tension is a factor in this determination.

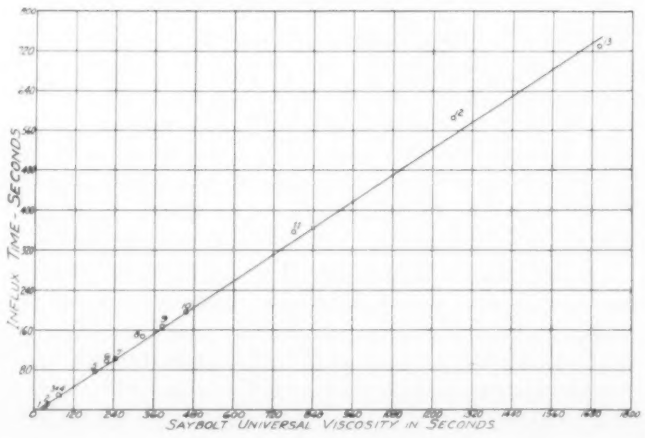
POUR POINT

Only one drop of oil is required for the micro pour test which gives results that agree very well with the conventional ASTM method requiring better than an ounce of oil. This test is illustrated in Figure 3. The bulb of a thermometer is dipped into the oil to a depth of three mm at room temperature. A 50-mm length of No. 29 gage copper wire is turned at one end to form a single loop four to six mm in diameter and then bent at right angles. The loop is applied to the drop of oil on the bulb where it adheres by surface tension and its stem serves to magnify the movement of the oil drop during pour test observations. The assembly is cooled in the customary ASTM pour test manner until no further movement is observed in the drop of oil when it is removed from the cold bath and held in a horizontal position for five seconds. The pour point is five degrees above the temperature at which no movement of the oil is observed. Figure 4 shows the correlation between micro and ASTM pour point.

SPECIFIC GRAVITY

Another important characteristic of an oil is its specific gravity. This property can be determined on less than 0.1 milliliter of oil. The measurement is made in micro pycnometers examples of which are shown in Figure 5. If the volume of oil is measured at the desired temperature and its weight determined with a micro balance, it is possible to determine its density to ±0.003 grams per milliliter.

Figure 2 — Curve gives relationship between influx time and Saybolt universal viscosity.



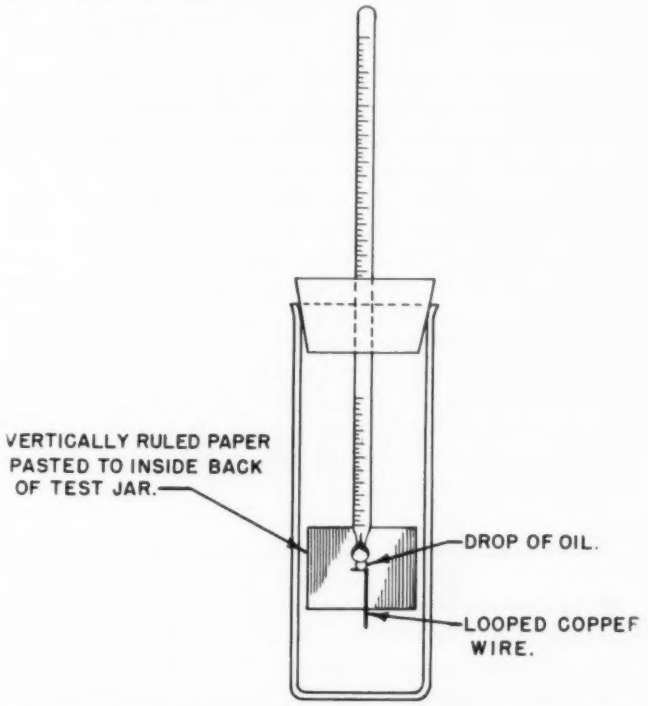
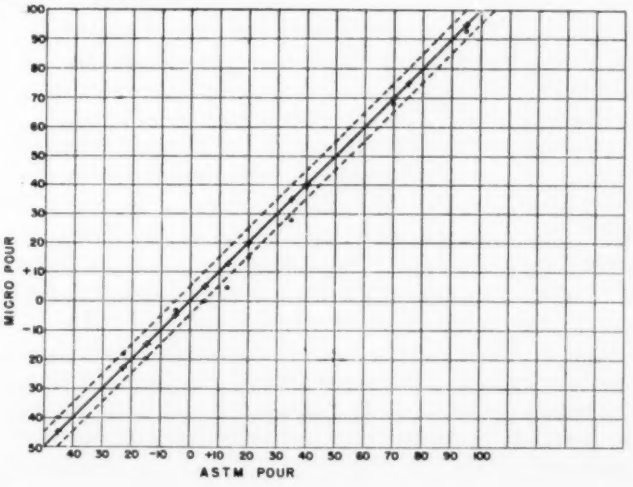


Figure 3 — Micro pour test requires only one drop of oil.

Figure 4 — Correlation between micro and ASTM pour point is very good.



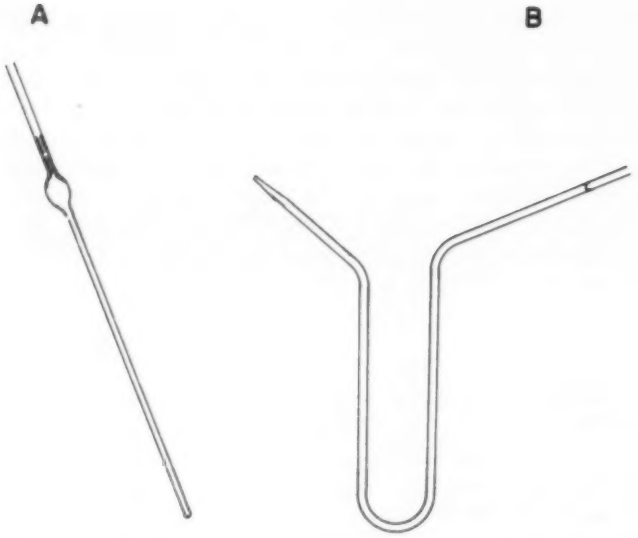


Figure 5 — Specific gravity is measured in these micro pycnometers.

ASH CONTENT

There are primarily two ways in which microchemistry is useful in determining ash content. One instance is when only a small amount of sample is available for ash determination. Micro-size crucibles are used to hold the sample and a micro balance is used to make the weighings. Special micro muffle furnaces have been constructed to provide even heat distribution. Their small size greatly reduces construction costs and permits a more generous use of quartz and platinum linings. There are other cases in which a large amount of sample is available, but the ash formed may represent only a trace of the original sample. In these instances macro equipment is used and macro quantities of samples are processed, but the ash must be weighed on a micro balance to provide the necessary accuracy.

SPECTROGRAPHIC ANALYSIS

It is often desired to know what metals are present in an oil sample. These may be additive metals or metals present due to contamination with dirt or other oils. The emission spectrograph is the work horse of the laboratory which provides us with this information. This technique is not usually thought of as a microanalytical procedure, however, if we consider the definition of microanalysis stated earlier we see that it is in fact a micro procedure. Ten milligrams of material is, in most instances, ample to obtain a satisfactory spectrum. Both qualitative and quantitative information are obtained from the spectrum.

All of the above tests may be performed on a few drops of oil. The first three are nondestructive and, after they have been completed the ash may be run after which the spectrographic analysis is made. The interpretation of the data will, of course, vary according to the particular problem. In general the information from the above tests will tell us whether the oil is what it is alleged to be, or if this is known for certain, whether it has been changed or contaminated. In the case of oils containing metallic additives we will have information on whether the correct amount and kind of additives are present.

DEPOSIT ANALYSIS

Very often samples of used oils contain undissolved materials, the identity of which is necessary in order to solve a particular lubrication problem. Many micro techniques have been devised to handle this problem. These materials differ widely in their origin and nature and require an analysis which may be very limited or quite extensive depending on the individual case.

The microscope is an invaluable aid in this type of analysis and often a good look is sufficient for a skilled analyst. Metal particles, rust, sand, fibers and other extraneous materials are easily identified. A determination of ash content and a spectrographic analysis as above also provide valuable information. X-ray diffraction is another powerful microanalytical tool which is invaluable in samples of this type.

In the investigation of lubrication problems, sludges or deposits are a common phenomena and their identity is important. It is possible to obtain useful information as to the nature and origin of these materials using only very small amounts.

A small glass centrifuge tube is used in the quantitative determination of solubility of a deposit in pentane and benzene-methyl ethyl ketone. A sample of 100 milligrams or less is weighed into a centrifuge tube. Solvent is added and mixed with the sample. The tube is centrifuged in a small-scale centrifuge and the clear supernatant solvent is transferred to a micro beaker. More solvent is added, and the sample extracted several additional times until the supernatant solvent is colorless and free from dissolved matter. After drying, the residues in the centrifuge tube and micro beakers are weighed.

The pentane soluble material is the oily component. By using the techniques described earlier the type of oil used in the system can be ascertained.

The benzene-methyl ethyl ketone soluble fraction or oxidized product is tested for metal soaps by ashing and determining the metal present spectrographically. The metal soap is decomposed by acid and the acidic fraction separated and examined.

The benzene-methyl ethyl ketone insoluble material or carbonaceous and mineral matter is given the same type of microscopic examination as the original deposit. Carbon is determined by the micro combustion train and the ash remaining from this determination indicates the amount of mineral matter present. X-ray diffraction analysis is frequently used to furnish identification of specific inorganic compounds present in the insoluble material.

The paper has described briefly some of the micro techniques which might be used in the analysis of lubricating oils. Other techniques are available such as neutralization number, saponification number, flash point, vapor pressure and color. Sometimes it is desirable to obtain an ultimate analysis and techniques for determining carbon, hydrogen, oxygen, nitrogen, sulphur, halogens and phosphorus are well established.

Another aspect of microanalysis has been only briefly mentioned. This is the field instrumental analysis. All of the modern instruments used in petroleum laboratories today may be classed as microanalytical tools. Emission spectroscopy, x-ray diffraction and fluorescence, mass spectroscopy, infrared and ultraviolet

spectroscopy, gas chromatography, and electron microscopy are among the principal ones.

SUMMARY

Microanalytical test procedures have a definite place in the modern petroleum analytical laboratory. Normally problems that have no other means of solution can be solved effectively by information that can only be obtained through microanalytical techniques. Reduction in a magnitude of operations frequently permits analyses to be carried out more rapidly and with more certain results than with conventional analytical procedures. When intricate apparatus is required for a determination, it is often easier and more economical to construct the unit on a micro scale. Reactions can be controlled more easily on a micro scale, and in cases where some safety hazard may exist, the use of micro techniques can materially reduce the hazard. Economy of operation is effected by micro techniques in cases where the required reagents are very expensive.

In those cases where micro techniques are used of necessity due to limited amounts of sample, the selection of procedures and order of testing must be planned carefully. Those test procedures which will allow substantial quantities of the sample to be recovered for further testing should be applied first. Insofar as it is possible, only those procedures expected to aid substantially in solving the problem should be used. In this regard, it is necessary in many cases to employ procedures indicated by results obtained from previous tests on the samples.

The future holds promise of more difficult problems for the microanalyst. Petroleum products are increasing in type and complexity. The equipment to which these products are applied is also being more complex with smaller assemblies and more critical lubricating requirements. These factors result in an increasing number of problems for the analyst, many of which require micro techniques.

Discussion

PRESENTED BY

JOHN SIMON, Lubrication Engineer, National Works, National Tube Div., United States Steel Corp., McKeesport, Pa.

F. M. ROBERTS, Supervisor, Analytical Dept., Texaco Research Center, The Texas Co., Beacon, N. Y.

C. T. LEWIS, Chief Lubrication Engineer, Republic Steel Corp., Cleveland, Ohio

John Simon: To the advantages listed by Mr. Roberts in favor of Microanalytical Testing we may add the ease of packaging and mailing samples, particularly where the laboratory receives samples from all over the country, and also simplified is the problem of storage and disposal of the samples.

The need for converting large scale functional tests to small dimensional tests has been recognized by ASTM with the adoption of the Quarter Cone Grease Penetration Test, Method D-1403-56T, which requires only five grams of grease. Another test, D-1404-56T, describing a method of Detecting Deleterious Particles in Lubricating Greases requires only one gram of material.

We have also investigated the ball and cup microviscometer. This test was developed in England and is used as a rapid field test for determining absolute viscosity. It requires only two or three drops of oil.

One test that would make an ideal subject for minimization is the Timken Fluid E.P. Tester. In addition to being quite bulky, it requires a gallon sample for each test, with a backlog of 15 or 20 tests this can really "clutter" up a laboratory.

F. M. Roberts: The reduction to micro scale of some of the tests, such as the Timken test and some of the other performance tests which have to be run on lubricants to evaluate their ability to perform is a large and not very well explored field.

I also agree with the comment on advantages. However, one has to be a little bit cautious about this because using some of the techniques I have described requires, from a practical standpoint, hand handling of the samples in the laboratory. It takes a lot of time and effort to do this.

This is quite a problem to handle something like this. Our laboratory normally handles some 80,000 to 90,000 samples in a year, and we are rushed to get through with these. To have to disrupt the routine to have someone hand handle these instead of letting them go through the normal course of operations certainly holds up things in the laboratory. There is that disadvantage.

C. T. Lewis: Mr. Roberts, you mentioned quite a few of the laboratory techniques, x-ray diffraction, infrared, etc. Chromatography, an old term, has been mentioned quite often in the literature within the last few years.

I have asked questions as to successful applications as far as petroleums are concerned and have not been able to get too much information. I wonder whether or not you had tried, say specifically, elution chromatography for determining any of the metallics as compared with spectroscopy or any of the other methods that have been mentioned?

F. M. Roberts: I purposely avoided that subject. That is a subject upon which volumes and volumes have been written and I can say yes, we do use it. Chromatography is an extremely powerful tool, especially in a petroleum laboratory. It can be used for separating components of mixtures which are nearly impossible to separate by other techniques.

Along this line, I think the most significant development in analytical chemistry in the last 50 years has taken place within the last five years and this is in the field of gas chromatography. This was developed in England. It is truly a micro technique, too. Five micro liters is an adequate sample for analysis. It enables one to make separations and analyses in a very short time which we either could not make before or which took us days to do. So the field of chromatography is very active. We have a very active group in it both in the liquid phase and in the vapor phase. The literature is full of it, especially in gas chromatography. It certainly is something not to be overlooked.

An ASTM method for determining the hydrocarbon composition of gasoline, for example, is the fluorescent indicator adsorption method. It is a chromatographic method and a very simple procedure. It requires only a small amount of sample and allows one to make a rapid determination. ▲

Basic Refractories

by MERVIN A. FAY, Manager, Basic Sales
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IN America today, there are about 200 open hearth furnaces using basic refractory roofs. Three years ago, in September, 1956, a paper entitled "The All-Basic Open Hearth Furnace" reviewed the development of basic refractories usage in America and abroad to that time. There were then only nine such furnaces in America. Fifteen months later, in January, 1958, six more all-basic furnaces had been added. This growth of over 50 per cent in such a period was noteworthy in itself, but the more than ten-fold growth in use of basic roofs during the subsequent 18 months is phenomenal. It represents an unprecedented change in open hearth practice and in the refractories industry.

Mr. Clarence Randall, while President of the Inland Steel Co., once said that the major developments in the steel industry do not result from radical discoveries; rather, they result from a multiplicity of small jobs well done. This is equally true of the refractories industry.

Many improvements of basic refractories have been achieved during the last half century. Most have not been individually outstanding. But the summation of these improvements have brought about the successes of basic refractories, not only in open hearth roofs, but in bottoms, front and backwalls, ends and regenerators of open hearths, as well as in electric furnaces and many other applications.

THE DEVELOPMENT OF CURRENT BASIC REFRACTORIES

Fifty years ago, basic refractories encompassed two materials, calcined magnesite either as grains or burned brick and chrome ore either as natural lumps, ground material or burned brick. Raw materials came from natural sources and were used without beneficiation. Neither the magnesite nor the chrome ore served adequately in the open hearth furnaces of that day.

The magnesite material, impure by today's standards, and insufficiently calcined, shrank on exposure to high temperatures and could not support much load. The chrome material, by itself, had notably poor resistance to iron oxide vapors or slags and to reducing atmospheres. Both spalled quickly with rapid temperature change. Still, both had properties of chemical attack resistance which made them better than siliceous or aluminous materials for some open hearth applications.

In bringing these two embryonic materials to today's fruition in the all-basic furnace, the most important steps have been:

1. Development of chrome-magnesite and magnesite-chrome compositions which enhance the attributes of both materials while subduing their deficiencies.
2. Invention of chemically bonded basic refractories which are more resistant to spalling caused by thermal fluctuation.
3. Development of steel-plated basic brick which further resist thermal spalling and provide bonding of adjacent brick.
4. Discovery of gap grain sizing of brick raw materials to promote ultimate density of brick product.
5. Use of high forming pressure in brick manufacture and the development of suitable mechanical and hydraulic presses to yield greater brick density.
6. Improved methods for beneficiation of raw materials, such as flotation, particularly for natural magnesites, to remove deleterious impurities.
7. Development of the process for producing relatively pure magnesia from seawater or brine.
8. Improved calcining procedures for magnesites to increase grain density and decrease porosity.
9. Increased knowledge of how to adjust mixtures of basic materials to promote desired characteristics of brick by varying particle size and/or raw material components.
10. Discovery of internal steel plating which nearly eliminates sheet spalling of basic brick.

Of all these improvements only one has had outstanding effect on the sudden swing toward basic refractories. This is the development of double internal steel-plated brick.

Single internal plates in basic refractories were first tried about ten years ago. They provided minor improvement of the brick in resistance to spalling. When double internal plates were tried four years ago, a substantial increase in spalling resistance was immediately apparent. In many cases, brick life was increased 25 to 50 per cent. The benefits of this striking change were broad, with marked increase of the spalling resistance of all unburned basic refractory compositions. This permitted much wider application of basic refractories.

However, all of the developments in the production of improved basic refractories were needed to produce today's successful basic brick. Still further improvements can be achieved.

OTHER CAUSES OF THE SUDDEN SWING TO BASIC

It is also necessary to look to other fields for the causes of the sudden change in open hearth refractories usage. These areas are not hard to find.

Open hearth operating practices have changed tremendously in a relatively short period. Much higher fuel input rates, the use of oxygen for decarburization and/or combustion, and other similar means for raising production rate, have become the rule rather than the exception in many shops. These practices created furnace conditions that caused extremely fast wear of silica roofs. A more resistant refractory became a necessity. Current basic products met this need.

The success of basic roofs on hard driven open hearths stimulated further trial of similar installations on furnaces where operating conditions had not been changed.

For The Steel Industry

Here also, the long predicted success of basic roofs was demonstrated in overwhelming numbers of trials.

This swing to basic did not result from the changes in brick materials and in open hearth practices alone. Major changes in basic roof design and construction technique were involved. These changes are largely simplifications which represent a return toward long established masonry practices with a few modifications to suit the peculiar needs of the basic refractories. This not only makes the use of basic refractories easier, but has marked effect on economy. Costs are drastically decreased, construction time and labor are cut. Much of the mystery concerning the use of basic brick has disappeared. Discussion of details of these changes in the design and construction practices now used is a principal subject of this paper.

PRIMARY CAUSES OF WEAR OF BASIC REFRACTORIES

The factors which have greatest effect on the life of basic refractories fall into two classes, those related to furnace operating characteristics or practices and those related to design or construction. Of these, furnace conditions are usually the more important in determining the life and success of basic installations. However, proper design and construction can enhance the value of all basic refractories but poor design or construction can cause rapid failure of any basic refractory.

Different basic refractories have different attributes which meet the requirements of a given set of furnace conditions with varying success. Selection of the refractory to be used is usually made on this basis even though proved knowledge of the exact combinations of basic refractory raw materials, grain sizes and production methods which will best meet the conditions is far from complete.

The more important furnace operating conditions which affect basic refractory life are:

1. The temperature of the exposed refractory face.
2. The amount and frequency of temperature changes which occur.
3. The condition of the atmosphere close to the exposed brick face, whether oxidizing, reducing or fluctuating.
4. The amount and kinds of flux brought to the brick by the furnace operation.

In general, the preferred situations which promote

> *. . . . in a relatively short period of time basic refractories are taking over in the open hearth furnace, applications are also being found in converters and electric furnace plants . . . . improved materials, longer life and resultant economy are basic (prime) reasons for change-over . . . .*

basic refractory life include:

1. The furnace temperature kept at optimum level for practical operation.
2. The least amount of thermal fluctuation that is practicable to the operation.
3. The elimination insofar as possible of any reducing conditions in contact with the refractory. Strongly oxidizing conditions would be helpful. Fluctuation from oxidizing to reducing is very harmful.
4. The least exposure of the refractory to fluxes or impurities from any source.

The variability of these factors which affect refractory wear can be tremendous from one installation to another. In fact, the predominant wearing factor can change from one hour to the next in a given furnace operation. The factors are not beyond some control, but outside influences can determine them. For example, if, in an open hearth, high scrap charges become necessary, but only light scrap is available, the resultant long charging time would cause greater furnace temperature fluctuation than would be the case under different conditions. Other similar situations can and do occur.

Four different but interrelated furnace operating characteristics which affect refractory wear have been listed. Two widely variant but fortunately, to some extent, compensating refractory materials are combined to meet the wearing conditions. The refractories are composed of at least six major oxide components and many trace oxides. Each major component and some trace materials can combine, in certain relationships, to form new compounds, which, if present, can have as great effect on refractory properties as the basic components. Each of the components and compounds has different reaction to the wearing characteristics. Any one could be determinant in single situations. The

possible combinations of wearing and resisting factors approach astronomical numbers.

No simple solution to so complex a problem is likely. Easy criteria, such as magnesia content or grain sizing, can be only partial measures of the wear resistance of basic refractories.

Despite this complexity some knowledge of the refractories which work well in various situations has been gained by trial and error. In every case where a satisfactory solution of the problem—wearing properties versus refractory resistance—has been found, it represents a compromise between the different abilities of the refractory components to oppose the wearing conditions.

With any compromise, complete satisfaction of the elements in conflict is impossible. However, with acceptable compromise, profitable results accrue.

In view of this, no single basic refractory can be a panacea for all conditions. Instead many different basic brick will be developed to meet special requirements.

To some, this might appear a very discouraging situation. This is not the case. From experience we know that we have several basic products which withstand conditions sufficiently well to permit profitable operations. Only long experiment and comparison of these and new products still to be developed can provide the experience needed for greater understanding of these matters. Meanwhile, as this work progresses, millions of tons of steel will be produced profitably, in furnaces using today's basic refractories.

DESIGN AND CONSTRUCTION FOR BASIC REFRACTORIES

Good design and construction practices which promote basic refractory life are better known and understood than the relationships between furnace conditions and basic refractory components.

Many different basic brick constructions have been used and observed. Careful study of these installations shows that all the more successful arrangements incorporate two cardinal principles which are closely related. These are:

1. Any movement of the basic installation and particularly the hot face of the refractory should be minimized.
2. Stresses which can apply to the hot portions of the refractory should be kept low. Support or moderate confinement of the hot portion of the brick appears helpful but any stress that can cause deformation or movement of any sort is harmful.

If these two engineering principles are followed, tremendously wide latitude of design and construction technique are possible. Conversely, if these factors are ignored and movement and/or stress is excessive, rapid failure of virtually any basic refractory can result.

BASIC REFRACTORY APPLICATIONS

All of the foregoing discussions are of a general nature, applying to all basic refractories and applications. Discrete applications can be discussed more specifically.

Open hearth roofs—The recent large extension in the use of basic refractories is in open hearth roofs, although other furnace parts are steadily increasing their use of basic brick. The roof usage is largely new while other applications are comparatively well known. Therefore, the discussion of basic refractories in open hearth roofs is more extensive than discussion of their use in other furnace parts.

Almost all American basic roofs are built with brick containing double internal plates. These bricks are also rapidly replacing the burned refractories which were used for basic roofs in Western Europe.

Both chrome-magnesite and magnesite-chrome brick compositions are used satisfactorily. Basic roof brick of either composition usually have some common characteristics. For example, the chrome ore component of the brick is normally confined to the coarse grained fraction of the brick mix and in almost every case the brick contain double internal plates.

Some tend to favor the magnesite-chrome composition because of the greater resistance to iron oxide attack of such brick. Others favor the chrome-magnesite compositions because of their lesser tendency toward shrinkage at high temperatures. To date, there has been no substantial difference in service life obtained from the two types of brick except in isolated instances.

There is no direct competition between chrome-magnesite and magnesite-chrome materials. Instead there are two known types of brick which can serve well in open hearth roofs. Exact knowledge of which brick, if either, will provide best results for any particular furnace awaits the accomplishment of much more experience than has yet occurred.

In the field of basic roof design and construction, fairly complete and definite knowledge of how to proceed has been gained. At present we have arched roofs with high rise and low rise, ramped roofs, suspended roofs and sprung roofs and various combinations of sprung and suspended arrangements. Some are held up, some are held down and some are both, some have large expansion allowance, others have little. Some are laid loose, others are tightened with jacks. Yet almost all are reasonably successful.

As long as any of these designs provides the essential minimum movement and low stress at the refractory hot face within fairly wide limits, the exact details of how the design does this is unimportant. To demonstrate that widely variant constructions, such as sprung and fully suspended arrangements can provide similar hot face conditions, the following discussion is presented.

So-called "sprung" basic roofs usually include transverse hot face expansion allowance while none is provided at the cold face. With this situation, when the roof centers are dropped, the hot face is slightly open and the entire arch is "sprung," only at the cold end of the brick. The hot face of the brick is suspended from the cold end of the brick by the brick itself. Sprung roofs are held down in this condition. All the brick are plated and virtually all include internal plates. On heating and operating the furnace, the plates quickly oxidize and absorb into the refractory materials for a considerable distance back from the hot face. This provides considerably more space than can possibly be taken up by thermal expansion of the brick materials. It is true that the hot ends of the brick, particularly those containing any appreciable amount of chrome ore, can

grow slightly, filling any voids. The brick in the area where this occurs are slightly pyroplastic, and if any appreciable lateral pressure were exerted on them they would deform. Thus, throughout the life of a "sprung" basic roof the hot face of each brick is suspended from the cold end by the brick itself. The conditions at the hot face are the same as those in a fully suspended, large expansion allowance arrangement.

Many may disagree with the idea that all the widely different roof designs provide the same hot face conditions. However, when the same bricks appear to give best service consistently in designs of wide variation, yet can fail rapidly if not properly constructed, it seems likely that similar conditions do occur at the hot face of the successful, though widely differing designs. This argument would be extremely difficult to prove because the stresses involved at the hot face are most difficult to calculate or measure. As long as successful results are obtained, the argument is academic. Recitation of the preferences for designs of various successful roofs is of more interest than argument of theory.

Roof Span

Successful basic roofs are now operating with spans from under 15 feet to more than 24 feet. There is no reason to fear spans of 30 feet or more.

Roof Length

There is no limitation to the length of a basic furnace roof section as long as adequate transverse support or suspension is provided.

Roof Rise

The optimum amount of roof rise for basic roofs is a controversial subject. Many prefer high rise values of over two in. per ft of span and as much as 2½ in. per ft of span, if possible. Yet several successful arched roofs have operated with rise values of only slightly more than one in. per ft of span.

Constant rise per ft of span for different spans does not provide equal radii. The radius of the arch is more directly connected with the stress applied to any individual brick than the empirical value of rise per foot of span.

However, if the skew locations are unchanged for any given furnace, and the rise per ft of span is increased, the roof crown is removed further from the flame. Also, the horizontal thrust of the skews on the arch is decreased. The first of these effects is definitely beneficial to the life of the roof and the second is certainly not harmful and may be beneficial.

If high values of rise per ft of span are not possible because of problems of clearance, this does not preclude the use of basic roofs. However, with flatter roofs the use of suspension is highly desirable to decrease the greater horizontal thrust exerted on the brick by the skews.

In summary, if convenient, high rise per ft of span is attractive. However, sprung roofs have stood satisfactorily with rise as low as 1¾ in. rise per ft of span. Below this value, the use of positive suspension is strongly recommended.

Roof Thickness

Roofs from 9 to 15-in. thickness have been used. Many have been of uniform thickness while others have had 6-in. wide ribs which are usually three in. thicker than the 12-in. wide intervening valleys. In one or two cases, ribs only 1½ in. thicker than the valleys have been used satisfactorily. Drop sections at front or back or both, have also been used, and in some cases in ribbed roofs, solid sections have been filled in between the rib courses at front or back.

Roof thickness has usually been chosen with an attempt to match roof life to the life of other furnace parts. In some cases, after first trials, thickness has been made either greater or less to try for better balance and resultant greater economy. Similarly, thicker roof sections have sometimes been added to strengthen fast wearing areas and achieve balance. Wear patterns of basic roofs have not been consistent from furnace to furnace, nor do they follow silica wear patterns. Successful tailoring of roof thickness to provide the desired campaign length with little or no patching can contribute much to the economy of current roofs but must be learned by experience.

Most suspended roofs have been of uniform thickness while most sprung roofs have been ribbed. A few suspended, ribbed roofs and a few sprung, uniform thickness roofs have been used. It seems logical that ribs offer some additional stiffness to sprung roofs that a suspended roof does not need.

The brick cost of a uniform thickness roof with tab brick for suspended construction is almost the same as the brick cost of a roof with valleys of equal thickness and ribs three in. thicker, but all without tabs.

With ribbed roofs, the hold down devices contact only the tops of the ribs and are cooler. This probably extends the life of the hold down beams although the hold down beams for uniform thickness roofs have been reused in several instances.

Ribbed roofs, in providing a gap between the valley sections and the hold down beams, are somewhat easier to clean of kish and dust accumulations.

In summary, wide choice of roof thickness is possible. For greatest economy, the choice should be made to obtain roof life equal to the life of other furnace parts, or some multiple thereof. The decision as to whether rib and valley or uniform thickness arrangement is to be used is usually determined by factors other than roof thickness. Either arrangement is satisfactory.

Brick Shapes

An overwhelming majority of basic roofs have been built using key shaped brick. Most have had a 4½ in. outer chord and three-in. thickness.

A few roof sections have been built using 4½-in. wide wedge shapes. Other roofs are being tried using 6-in. wide wedges. With both sizes of wedge brick, not enough experience has been obtained for safe evaluation. More trials will be made with both 4½ and 6-in. wedge brick.

Wedge brick offer some slight construction advantage in that the roof rings are wider and are less likely to tip as the brick are being laid. With proper setting of centers, as will be described later, difficulty of this nature with the narrower key rings can be minimized.

The chief reason that key-shaped brick have been preferred is that their internal plates lie in radial positions, perpendicular to the skew thrust of the arch. In

this position, as they are oxidized and absorbed by the brick, they provide ample transverse expansion and growth provision. If wedge brick are used, the internal plates lie along transverse positions with the arch thrust across their edges. In this position they provide longitudinal expansion allowance, which is not needed, but none across the arch.

In wedge roofs, there are one and one-half times more joints across the arch than in key roofs. Each joint contains two plates. Wedge roofs have only ¾ as much metal in plates lying in radial positions as internal plated key brick roofs. This may be enough. However, the external plates do not act exactly as do internal plates. External plates in the cooler parts of the joints tend to oxide and swell, not being absorbed by the brick. Growth of this sort can tend to cause buckles. Thus, if wedge brick are to be used, the use of more frequent hold downs appears advantageous. If this is done, the cost of extra hold downs outweighs the slight construction advantage of wedges. If wedge brick are used, the use of greater hot face expansion helps to counter the lesser tendency of the external plates to absorb into the brick and is recommended.

Skew brick for basic roofs are of basic material steel plated on their two flat sides. Frequently, designs other than those used for silica roofs are preferred.

Basic skews are not so strong as silica skews. If they are not supported by steel-work or under-pinned by walls, the unsupported sections can break away. Such conditions can occur above door openings. In these areas, is some cases the skew design has provided that a substantial portion of the roof thickness be supported only by the skew brick which is cantilevered from the skew channel. Breaking off of the unsupported front section of the skews frequently occurred. This exposed the side of the first course of roof brick and hastened rapid wear in this area.

Revision of the skew design so that virtually all of the thrust is transmitted to the skew channel without setting up shearing stress in the skew brick eliminates this problem.

In most cases, high rise roofs have been used with basic construction. This necessitates the use of new skew shapes if the skew angle is to be close to a radial position. If the skew angle is to deviate from a radial position, it is preferred that it lie back from the true radial position.

Summarizing the brick shapes used in basic roofs, key shapes have been predominant to date. Some roofs using wedge shapes are currently being tried and additional trials will be made because they offer slight construction advantage. Key shapes afford positioning of internal plates that is believed to provide better expansion and growth allowance characteristics. For first trials of basic roofs the key shapes are recommended. Skew brick should have full support. Usually new skews must be designed.

Other important design factors—Aside from basic roof size and shape, other important construction design factors include suspension, hold downs and expansion provision.

Radically different ideas have been expounded on these subjects. Some condemn suspension, others espouse it. Both have successful basic roofs. Most have rigid hold downs (some heavy, some light), but some have used hold downs which are allowed to yield to some extent; still others have none. Some build extremely tight roofs, others extremely loose roofs. The following is an attempt to resolve these differences of opinion.

Suspension

When both suspended and sprung constructions can be successful, the choice of whether or not to use suspension must depend on factors other than the success of the roof. Study of current installations shows this to be true. The chief factors which determine whether suspension is used are:

A. Conformation of the roof structure.
B. Thickness of the roof.
C. Desired length of furnace campaign versus ease of construction and repair.
D. Safety and insurance value of the suspension.
E. Ultimate economy of the construction.

A. *Conformation of the roof structure*—Roofs of low rise per ft of span need suspended construction to decrease the strong horizontal skew thrust of a large radius roof. Further, in roofs of low rise, many straight brick may be used in the arc. These could slip if not positively suspended. Suspension prevents any downward deformation of the roof. In the above described situation it is strongly recommended.

B. *Thickness of the roof*—Thin roofs or those which are thin in relation to the span should be suspended to improve their mechanical stability. Also, if the roof is expected to last for a long period after it has worn thin, suspension is recommended for the same reason. There have been several instances where the suspension of thin roofs, both as built and ones which have worn thin, has increased their life to a marked degree.

C. *Desired length of furnace campaign versus ease of construction and repair*—The desired life of a basic roof can determine whether or not it should be suspended. If a basic roof is expected to last through several furnace end or slag pocket runs, withstand cold shutdowns and perhaps extensive patching to get all the life from every brick in the roof, suspension is attractive. If, however, the furnace roof is expected to withstand a shorter, high-speed run with rapid furnace rebuilding to provide availability, the advantage of suspension is more doubtful. In this latter situation, the roof is seldom the reason for shutting down the furnace.

Clogged slag pockets, checkers and flues or worn ends are more likely to cause the campaign end. When this happens, the basic roof is usually good for more heats but might not withstand another full campaign. It is dismantled and a new roof installed to insure a subsequent trouble-free campaign. In this practice, simplest sprung construction promotes easy and rapid rebuilding.

Suspension offers great advantage in prolonging the run of a basic roof. Many smaller plants with small maintenance crews that cannot accomplish rapid complete rebuilds but can achieve fast patching, find suspension more than warranted through greater furnace availability and lower cost. Such furnaces try for longest possible furnace campaign length, taking short shutdowns for patching as needed.

In some such cases the cost and time spent for building roof centers is considered particularly onerous. Ac-

cordingly, suspension is preferred in an arrangement which permits hanging of the roof without use of centers.

The choice of whether or not basic roof suspension should be used is dependent in the individual case on how the furnace will be operated, what is wanted from the furnace and how fast it can be rebuilt and/or patched.

D. *Safety and insurance value of suspension*—A fully suspended basic roof cannot fall in, either while operating or when cold.

In obtaining long furnace runs with basic roofs, there is a long period during which the entire arch or portions of it are thin. Such arches are not, by themselves, very stable mechanically. Also, patching of the basic roof itself may be required. With suspension, there is no danger of large sections dropping in either during operation or patching.

The hazard to furnace crews from a roof section falling in during a heat is obvious. Further if any appreciable amount of basic roof refractory must be dissolved in the slag, metallurgical problems result. Basic roof brick contain substantial amounts of chrome ore which if added to slag make it thick, gummy and difficult to handle. Such a slag can cause delay, and perhaps an off grade heat. Savings of the cost of one such heat in most shops would pay for the additional cost of suspended over sprung construction for many furnaces.

Many sprung basic roofs have been patched satisfactorily. In a few instances, holes opened in sprung roofs have grown uncontrollably as brick around the edges of the hole dropped before the patch could be keyed in. In each case of this sort, the roof patch followed another furnace shutdown by a few heats. This is thought to have contributed to the dropping in of the basic brick around the hole perimeter. Suspended roofs have withstood similar conditions without difficulty and have returned to service satisfactorily. Because of this, the completed suspended basic roof campaigns average considerably longer life than the completed sprung basic roof campaigns at one plant. The cost of the loss of one such sprung basic roof would pay the additional cost of suspended over sprung construction for many furnaces.

In summary, the safety and insurance values of suspended basic constructions over sprung constructions are substantial. The successful applications of many sprung installations show that the use of suspension is not imperative. Nevertheless, the attributes of suspended construction in assured safety should be considered in making basic roof installations.

E. *Ultimate Economy of the Construction*—All of the factors which influence the choice of whether or not suspension is used affect the economy of the operation. However, many of the possible benefits of suspension are intangible and cannot be accounted directly. The selection of suspended or sprung construction is frequently dependent upon personal opinion and estimate of their relative worth in each individual case.

Simple suspended construction using tab brick and common steel wire hangers can usually be incorporated in a basic roof design for small additional installed cost over that of a sprung roof.

Although tab brick cost somewhat more than identical brick without tabs, in most cases if suspension is not used ribs are, and the additional cost of ribs virtually equals the added cost of tab brick without ribs. Thus, in most cases, the brick costs can be considered about equal for sprung or suspended brick. The cost of steel wires for suspending a tab roof is less than $1000.00 for a large open hearth and is correspondingly less for smaller furnaces. Tab brick are suspended from the hold down steel normally provided. The only other cost for suspended construction is the labor cost for bending up the tabs on the brick and for attaching the wires. It is impossible to generalize on these costs because of the differing labor situations in different plants. However, with practice, these tasks can be accomplished rapidly with few men so that their cost should never be excessive. The total of these costs is not great.

With current construction it is possible to combine almost any amount of partial suspension with sprung arrangement by suspending selected portions of the roof. Determination of exact amount of suspension which yields greatest economy can only be determined by long experiment. Many attempts at such determination are in progress. For example, basic roofs with sprung ribs and suspended valleys or uniform thickness roofs with four suspended courses alternated with two sprung courses, are currently used. The extension of possible experiments in this direction is virtually unlimited. Such construction decreases cost while providing some suspension.

Suspended and sprung basic roof constructions both have applications in which either is much preferable to the other depending upon the individual circumstances. The furnace design, what is expected from the installation, the facilities for the construction and repair and the need for insured structural stability are all factors which affect overall economy differently in each case. Certainly suspension is not always a requirement, but neither is sprung construction adequate for every basic open hearth roof installation.

Hold-Downs

One of the chief innovations in American basic roof construction is the almost universal use of positive holding down devices. Some earlier American roofs had hold-downs and European basic roofs have normally included some holding down, but in most cases, the earlier constructions were not as firm and rigid. All of the earlier constructions included suspension.

Experience with sprung type roofs without hold-down or only partial hold-down arrangement has shown that hold-downs are essential to prevent early deformation and premature failure.

Hold-downs do much to prevent movement of the roof brick and also act to minimize stresses occurring at the hot face of the brick, if sufficient hot face expansion provision has been made. In these respects, hold-downs are believed extremely important to the success of most basic roofs. However, successful basic furnaces have operated without hold-downs. In such cases, expansion allowance has usually been large. Because of this, it is impossible to say that hold-downs are absolutely essential to basic roof construction, but it is certain that they exert beneficial effect on brick life when they are used.

Most hold-down arrangements consist of a number of longitudinal steel members placed directly in contact

with the roof at regular intervals across the arch. The space between these members has normally been about 3 to 3½ ft, although wider and more frequent spacing has been used. The members themselves have been of various sections from 2¼ x 2¼ in. tapping rods to 8-in. wide-flange "H" beams.

The longitudinal hold-down members are usually supported at each cross binding position by steel struts or hold-down jacks fabricated from pipe, plate or light structural members. These normally lie along radii of the arch so that they are parallel to outward thrust. They are designed to be installed easily and quickly after the roof has been built. This requires that they be adjustable to some extent.

Most hold-down struts or jacks also hold up the longitudinal hold-down members. By this means, if any suspension is to be used, the hold-down arrangement can also double as the suspension superstructure. This results in substantial savings in suspension costs.

The hold-downs do not have to be built from heavy steel members to resist great stresses. Apparently, the force required to keep a basic roof from buckling upward is not great, particularly if it is opposed before the buckle starts. The hold-down structure can be built from available steel in almost any plant. It is not necessary to secure any particular sections for this purpose.

The longitudinal hold-downs are usually in sections for easy construction and handling. Hold-down struts are arranged to accept the ends of two adjacent sections forming the joint between them. In most cases, the entire hold-down structure can be used through many furnace campaigns. It may be dismantled and rebuilt at each roof repair to facilitate bricklaying, although this is not a necessity.

Transverse Plates—A major extension of the holding down of the roof is achieved by means of transverse plates inserted between roof rings. Such plates are another innovation in American basic roof construction, although they have long been used for the same purposes in basic walls.

The first transverse plates used were hung from the furnace superstructure to provide some suspension for the crown section of the arch. The plates extended several inches above the arch to permit hanger arrangements. At the hold-down locations they had to be notched to allow for the longitudinal members. A logical simplification of the arrangement was to hang the transverse plates directly from the hold-down members, which were also held up, with the elimination of the separate plate hangers.

The transverse plates do provide some suspending action in the arch. However, it is thought that their major beneficial function is in the reverse direction. They stiffen the roof and inhibit upward buckling action as much or more than they suspend any brick in the roof.

3/16 or ¼-in. thick transverse plates have been inserted in every third to every sixth transverse joint (i.e., 9 to 18-in. centers). Where suspension has been used, they have usually been installed in every fourth joint (i.e., every 12-in.) with two courses of brick being hung on both sides of each plate.

Best design for transverse plates provides sectional pieces which can be handled easily by one or two men during construction. The sections should be separated either beneath hold-down beams or at staggered locations if between beam separations are more convenient. If the plate sections meet so that longitudinal joints between plate sections occur along the roof, some buckling action is apt to occur at this point.

While the transverse plates have provided very useful functions, they are expensive and somewhat cumbersome to install. It appears likely that the use of closer spacing of longitudinal hold-down members might obviate the need for transverse plates. This would probably result in savings as the hold-downs can normally be reused whereas new transverse plates must be provided at each roof replacement.

The plates must be burned or sheared to predetermined size and notched out at the hold-down locations. Burrs and rough edges should be removed. If the plates were burned to shape they usually must be straightened to prevent large open joints in the roof. Further, they must be attached to hold-down steel after installation. All of this represents considerable expense.

To date, few basic roofs have been built without plates, but with additional hold-downs. However, several such roofs have been proposed and it seems likely that some will be tried because of the probable savings of this arrangement.

If suspension were to be used in such construction probably the simplest and least expensive arrangement would be to attach bars across the longitudinal hold-down beams at convenient locations and hang the tab brick by wires from these bars. These bars could be reused many times. Thus, the elimination of transverse plates need not interfere materially with provisions for suspension.

Summarizing the situation concerning holding down of basic roofs, the use of adequate positive hold-downs appears very beneficial to all basic roofs and is an absolute necessity for sprung constructions. Current construction provides longitudinal members in contact with the roof held by radial, adjustable struts attached to the furnace superstructure. In addition, transverse steel plates between roof rings act as stiffeners for the roof, extending the holding down effect of the hold-down members. It appears possible that the use of more hold-downs might permit elimination of the transverse plates. This might save costs with no technical disadvantage to the arrangement.

Expansion Provisions

Another extremely important factor in current American basic open hearth construction is expansion provision. If stresses on the hot face of the refractory are to be kept low, expansion allowance is a critical factor.

Early, fully suspended American basic roofs usually had expansion provision more than double the amount needed to satisfy the requirements of the brick materials in both transverse and longitudinal directions. The expansion joints were usually equal at the cold face and the hot face of the roof. Such joints seldom closed at the cold face even though they closed quickly at the hot face. This violated the principle of keeping the stresses on the brick hot faces at a minimum. When the expansion joints were closed at the hot face only, any stress which developed applied directly to

the hot ends of the brick. To minimize this effect, there was a definite trend until two years ago to increase expansion provisions.

With the advent of the more recent constructions in which the much greater stresses of sprung construction were incorporated, but confined to the cooler parts of the brick by the use of double internally plated brick, it was found that the large expansion allowances were not needed. The plates reacted with and were absorbed by the refractory materials providing more than enough space to allow for thermal expansion. As a result, expansion provisions were drastically decreased.

In the longitudinal direction of the furnace, expansion provision was eliminated. It has been found that even with painstaking masonry practice, and the use of several hydraulic jacks to tighten successive 6 to 10-ft longitudinal roof sections, about 2 per cent of void space is still available for thermal expansion of the brick materials.

In the tranverse direction, no automatic expansion provision occurs. Therefore, some hot face expansion allowance is normally made. The amount of this allowance is usually from 0.5 to 0.75 per cent at the hot face with none at the cold face of the brick. This amount is considerably less than the theoretical amount needed. This allows for the expansion which takes place in heating up to temperatures at which the brick material starts to absorb the plates on and in them. The space provided by absorption or melting out of the external and internal plates of key shaped brick amounts to almost 5 per cent of the inner arc of the roof. This is much more than enough to allow for a theoretical expansion requirement of 2 per cent.

Internal plates have been highly effective in eliminating the need for large expansion allowance in held down basic roofs. They provide ample room for expansion and growth and help to prevent the occurrence of excessive stress at the hot face of the roof. If wedge shaped brick are to be used more expansion allowance is needed because of the difference in position of the internal plates in the roof.

CONSTRUCTION OF BASIC ROOFS

There are many details of construction that can shorten erection time and save costs. The more important of these are listed as they would occur during the building of a roof.

Setting of Roof Centers

Spacing and bracing—It must be remembered that a basic roof will weigh about 60 per cent more than a silica roof of equal thickness. Accordingly, if basic roof thickness approaches that of formerly used silica roofs, less distance between center ribs and more rigid bracing are needed for stability.

Particular care should be exercised in setting the forms to insure that they are alined with the toes of the skew bricks. If the centers are improperly positioned, the brick requirement of the roof will differ greatly from the engineered count.

Lagging—1-in. thick lagging is sufficient with center rib spacing of 2-ft or less. When using 4½-in. wide key brick for laying a basic arch, lagging width of no more than 4-in. is preferred. This provides a smooth arch curve. Wide lagging as is used in some plants, can cause unevenness and major discrepancy between engineered brick counts and brick requirement. If few extras have been added to the net count of brick required, this can cause serious difficulties.

Level—It has been found that by setting the centers at the knuckle positions about 1-in. higher than at the furnace centerline, the resulting slight slope helps to inhibit tipping over of the 3-in. thick key brick rings as they are being laid. This construction trick has been helpful in many cases.

Bricklaying

The most convenient place to start a basic roof is at the furnace centerline. Rings of brick are laid with three to eight rings being brought up from the skews at one time. Five to eight bricklayers with enough helpers can achieve rapid work on each end of the furnace in this arrangement.

The rings should be kept straight. It is not wise to rely on vision to determine the straightness of a ring. If, on using the straight edge, a bow is discovered, a wooden block should be placed against the bulged area and hit with a sledge hammer until the brick line is true. Never strike the brick directly with a sledge. If the brick line is checked every two ft along the roof, any correction is easy. Bricklaying at the skew position should not be far ahead of the ring closure positions to prevent "snaking" of the rings.

If tab suspended brick are being used, the tabs should not be bent up to suspending position before or as the brick are laid because they can become badly bent out of shape by men walking on the roof. The best arrangement is to bend the tabs up at the time that suspension wires are attached. Tab brick should provide easy pulling up of tabs at any time. If such provision for easy bending up of tabs has not been provided in brick manufacture, it may be necessary to clear them from the brick material by hitting them with a chisel or scutch near the bendline of the tab before they are laid in the roof.

Start of bricklaying—At start, a chalk line should be stretched across the center of the furnace. A 1 x 6-in. board should be nailed firmly to the lagging with one edge along this line. This provides a straight form for laying the first roof ring. After a 2-ft section of roof has been laid, the starting form can be removed and bricklaying can proceed toward both ends of the furnace.

Plate installation—Transverse plates are placed in the roof along with the brick. As mentioned earlier, transverse plates to be used between brick rings should be flat. If warped during fabrication they should be straightened. Burrs and rough edges should be removed. This is necessary so that the plates will fit tightly against the brick without excessively open joints. Open joints between plates and adjacent brick effectively destroy much of the value of the plates.

In installing a set of transverse plates, the first plates up from the skew brick should be set at a point about 2-in. up the arc from the skew face. It is important that some means be used to aline the notches in which the hold-down beams will fit with similar notches in preceding sets of plates. Boards cut to fit the notches which can be slid forward as each new set of plates is installed can fill this need.

Expansion joints—The most commonly used transverse expansion allowance arrangement has been to install 1/16-in. thick asbestos paper expansion spacers at the hot face in every other joint across the arch. This provides about 0.75 per cent allowance. In some cases 1/8-in. thick spacers have been used in every third joint across the roof. This provides about one per cent allowance. Another popular arrangement provides 1/16-in. spacers every other joint for eight spacers up from each skew and every fourth joint for the balance of the arch. This arrangement provides about 0.5 per cent total allowance. All of these arrangements have performed satisfactorily.

In a few instances, expansion spacers have been left out in some roof sections either by plan or inadvertently. Observation of these areas in service has indicated somewhat faster early wear although little difference in total life could be determined. To avoid such early wear, the use of expansion provision of at least 0.5 per cent is preferred. Some extra transverse expansion provision does not seem to change the rate of wear, but too little causes slightly faster early peeling.

Keying—Basic arches can be keyed at three or five positions across the arch. When three keys are driven, the driving distance is about 2½ to 3-in. If five are driven, the driving distance is about 1½ to 2-in. The crown key should always be driven first. The key shape used for driving should be a brick of slight taper. The driving of either three or five keys provides about equal tightness so that when the centers are drawn, the roof does not drop more than ½-in. In many instances, no drop can be observed or measured. This represents tight keying, but it should not be so tight that the arch rings are lifted from the centers as the keys are being driven.

At the start of construction, it is recommended that no keys be driven until at least eight feet of roof has been laid. Then only the keys for the center two feet should be driven. Keys should not be driven closer to the mason working the crown key position. A convenient way to provide uniform keying is to hold the keys up on a block of proper thickness and 15 or more inches long. Such blocks are set at the key positions with a small wedge (approximately ¼-in.) under their outer end. Four rings can be constructed before the block is pulled out. To remove the block, knock out the wedge and it comes out easily. Driving of the keys takes some of the weight of the roof off the supporting forms. Further, it permits other trades to start on their part of the roof installation, as for example, millwrights setting the hold-down steel. Such coordination reduces rebuilding time.

Jacking of the roof—Some plants use a practice in which several jacks are applied to tighten the brick in a longitudinal direction as each 8 to 10 ft section is completed. The reason for this is that at one plant, when a roof was installed and allowed to stand on the center for a period of weeks, some shifting occurred and some rings tipped when the centers were drawn. Jacks were applied and the roof was tightened sufficiently to allow the installation of three additional rings of brick. This is thought to have been an unusual case. Many plants which have not used jacks appear to get equally good results. It is probable that the use of jacks would tend to correct the defects caused by warped plates.

Completion of the basic section—If the basic roof section covers the main roof only, and silica port roofs are to be used, ½ to ¾-in. thick joints filled with celotex board or other expansion spacers between the two sections are recommended. This is done to provide slippage between the two sections during heat-up. The basic roof, being held down, should not rise but the silica sections should rise two to three in. at the crown position. For this reason it is also recommended that silica sections which adjoin basic sections should be laid with the crown two to three in. below the crown of the basic section so that, after heat-up, the two sections will be approximately level.

If the basic roof section extends to the furnace endwall, it should extend over about one third of the thickness of the wall. The section of the top of the endwall which lies beneath the roof should be at least 1½-in. below the roof to allow for vertical expansion of the endwall. The remaining two thirds of the endwall should be bricked up with the brick butting against the sides of the roof brick. This vertical section of the endwall should be supported laterally by some compressible material and backed by solid steel work.

Steel Erection

Before bricklaying is completed some erection of steel hold-downs and/or suspension can begin.

Hold-downs—Longitudinal hold-down members can be set in place as soon as a section of sufficient length has been keyed. The connecting of each set of transverse plates with steel straps or rods over the top of the hold-down members can then start. Further, the installation and pinning of the hold-down struts or jacks can be done as soon as two adjacent sections of longitudinal members are placed.

In a few instances the hold-down jacks are not pinned until after the roof centers have been pulled. Good bricklaying does not permit any appreciable drop of the roof when the centers are drawn so that this practice is not considered essential.

Suspension—Wiring of tab brick can also proceed while bricklaying is still in progress. This should not start until the hold-downs have been placed and the transverse plate sets have been connected.

The suspension wires should be preformed with a hook on one end. The procedure is to bend the tabs up from the brick ends and engage the hook in two opposed tabs. The wire is then laid against the nearest transverse plate in a radial plane. The upper end of the wire is bent down over the plate either by hand or with a simple tool.

With proper scheduling, the attaching of suspension wires and/or the setting of hold-down steel can be completed very shortly after bricklaying is finished.

Drawing of centers—The center framework on which the roof is built is usually removed as soon as the bricklaying and the setting of hold-down steel are completed. This work is done in exactly the same way that it is done with a sprung silica roof. No unusual precautions are necessary. As mentioned earlier, if the roof has been keyed properly it should not drop more than ½-in. when the centers are removed.

With the completion of this work, the furnace should be ready for operation.

THE APPEARANCE AND TREATMENT OF BASIC ROOFS IN SERVICE

In general, the operation of a furnace with a basic roof requires no particular procedures different from those used for furnaces with silica roofs.

However, because of the differences in appearance of basic roofs as compared with silica and the importance of taking corrective action quickly if certain developments occur, various facets of the normal operation, appearance and treatment of basic roofs are described.

Initial heating up of basic roofs—Basic roof refractories, unlike silica, have straight line thermal expansion. There is no reason to heat them very slowly in the low temperature range (below 1500 F). The heat-up of basic roofs can proceed as rapidly as is safe for the other furnace parts.

In most cases, to insure against any damage, initial basic furnaces have been heated according to normal plant practice. In several instances, faster heat-ups have been made subsequently. In one case, hot metal was added to the furnace hearth shortly after the furnace chamber achieved a good red color. With the use of an oxygen lance, the first heat was tapped in less than 15 hours after light up. No apparent damage to the basic roof could be noted and a successful campaign followed the fast heating.

Heat-up rates of 150 to 250 F per hour do not seem to hurt basic roofs. With a heat-up rate of 200 F per hour the furnace will be ready for charging in about 12 hours. This is faster than the heat-up rate that can be used safely with silica roofs. Further work will probably show that even faster heating will not damage basic roofs.

The appearance and normal wear of basic roofs—The appearance of basic roofs in service is vastly different from that of silica roofs, throughout the campaign from heat-up to finish. There are also differences in the appearance of chrome-magnesite roofs and magnesite-chrome roofs although experts can be fooled if they try to determine which is which without advance knowledge.

During heat up of basic roofs, melting and dripping out of the plates between brick can sometimes be observed. This can cause the hot ends of the brick to appear concave. Shortly thereafter, a reverse situation is sometimes seen with the brick ends appearing convex or bull-nosed. This condition is sometimes followed by noticeable peeling away of the hot face of the brick. Such a peel can be as little as ¼ in. or as much as one to two in. It should be remembered in observing hot furnaces that the thickness of peels almost always appears greater than their actual amount. If internal plated brick have been used, such peels are usually considerably less than one in.

First peels have been observed to occur any time from as early as three heats to as late as 80 heats in different campaigns on the same furnace. In some cases no such peeling can be seen. No recognizable correlation between first peel and ultimate service life of basic roofs has yet been found.

In view of these things, first peels of basic roofs are not a cause for alarm. However, if appreciable peeling recurs frequently in any single area, trouble can be anticipated. This seldom occurs with the use of double internal plated brick.

Regardless of whether a first peel of a basic roof occurs or not, after a few heats have been made, the roof surface becomes rough. Brick joints tend to disappear and even the thick joints at the locations of the transverse plates may be hidden. This results from the accretion of iron oxide on the brick surface and from its reaction with the brick. This roughness of the roof surface is usually much more pronounced with chrome-magnesite roofs than with magnesite-chrome roofs.

In Europe, the development of a rough surface or "pelz" on a basic roof has long been regarded as evidence of satisfactory operating conditions and probable good basic roof life. This appears to be true with American furnaces also. The best appearance of a basic roof shows a rough surface with no apparent peeling. Such roofs usually have long life.

Such building of "pelz" causes subsequent peeling to appear much thicker than the actual amount of brick eroded. For example, on one basic roof without internal plates it was estimated that 24 in. of peel came from an original 18 in. thick basic roof in one area. At the end of the furnace campaign 6 in. of unused roof brick were intact at this location.

Normal war of basic roofs is a cyclic erosion of the hot face characterized by the loss of successive layers of the refractory. Before internal-plated brick were used, this cyclic peeling away of the hot face of the basic refractories was more apparent.

Such wear can occur as the result of faulty construction, thermal cycling, chemical attack of the brick or combinations of these things. The overlapping of these effects has been the source of much confusion in the understanding of basic refractory wear.

Double internal plates in basic refractories strongly inhibit inherent sheet spalling tendencies of the refractory material and, in proper arrangement, tend to correct structural causes of sheet spalling. While the advent of double internal plates decreased sheet spalling of basic roofs, the same factors which cause it are believed to cause gradual peeling away of the roof even though sheet spalling is not apparent.

In summary, basic roofs should appear rough throughout their life. When a roof shows recurrent peeling in a given area, this is evidence of rapid wear. A smooth hot face surface sometimes indicates this condition.

The development of red color and cleaning practices—Basic roofs show red long before silica roofs. Basic roofs can show red at 7-in. thickness; thus the development of red spots or areas on a basic roof is not necessarily a cause for alarm. Some roofs have operated for almost 400 heats with pronounced red areas and with no patching of these areas being required.

The accumulation of dust or kish on the outside of a roof contributes greatly to high temperature on the outside of the roof. If any appreciable accumulation is scraped away, a bright outside color will be found.

The effect of heating the entire brick to temperatures above red heat is not known, but it is felt that life would be longer if the outer surface of the roof were kept as cool as possible. This is definitely helpful for

the steel hold downs, the transverse plates and suspension wires. If such steel is buried in dust and heated above red heat, it oxidizes quickly and loses its structural strength.

As a result, most basic roofs are cleaned periodically. This can be done by blowing the dirt off the roof with an air or steam lance. In some cases, manifolds have been arranged so that the dirt can be blown off merely by opening a valve on the charging floor. Another means for trying to keep the roof clean is to use shields to collect the dust or divert it away from the roof.

Most roof cleaning practice is only partially effective. Hold down steel and the transverse plates form virtual traps for catching air-borne dust. Most basic roofs have some dust accumulation during most of their life. Furnaces in dusty areas are usually much dirtier than others. Even in these situations some basic roofs appear to perform almost as well as they do in areas where there is little dirt. In any case, cleaning of basic roofs is thought beneficial.

In a few cases where basic roofs have been clean but still show red, large fans have been mounted to blow air streams on the roof. When this is done, the red color disappears as soon as the fans are started. This practice probably helps the life of the brick but its use is not believed essential.

The development of roof buckles and their treatment—Upward buckling of basic roofs is apt to occur if they are not sufficiently held down, or if severe wear occurs in a small area. If buckling occurs and is allowed to progress, a hole in the roof is almost certain to form in the buckled area. Basic roofs should be inspected regularly for signs of buckling. The gradual opening of cold face joints is usually the first apparent change. If such action occurs, more hold-downs should be added immediately in the affected area.

Additional hold-downs similar to those initially used are sometimes not convenient. In this case, very crude arrangements can be used. The only requirement is that the movement be stopped. One simple arrangement is to place a steel plate immediately over the incipient buckle, weld it to a light structural member that extends upward in a more or less radial position and weld this member at its other end, to the furnace superstructure.

If such buckling action is observed and stopped before much deformation of the roof has occurred, no apparent damage to the roof results.

Furnace shutdowns—If it is necessary to shut down a basic roofed furnace no unusual practice need be followed. Similarly, the heating up of a used basic roof requires no special handling.

Furnace shutdowns represent severe thermal fluctuation, which undoubtedly cause damage to the basic refractories; because of this, they should be kept to a minimum. Further, the frequency of shutdowns can affect the basic brick. If two shutdowns are needed within a short period, a sheet spall is apt to occur.

Sheet spalling of the refractory hot face can occur at any shutdown. If this happens, it usually takes place during the period of production of the next 25 heats after the shutdown. However, sheet spalling after a shutdown is not automatic. Normal wear of basic roofs is cyclic, with successive layers of refractory being eroded away. Shutdowns speed this process. If the wear cycle is approaching the time at which the hot face layer would erode, a furnace shutdown could easily cause a sheet spall. If a newly exposed refractory face forms the hot face of the roof, the probability of such a sheet spall is small.

During furnace shutdowns some cracks may open in a basic roof. A transverse crack near the furnace centerline is common and other transverse cracks may occur. Longitudinal cracks usually open close to the crown position in suspended roofs. Longitudinal cracks are less frequent in sprung roofs but are sometimes found.

If two shutdowns have occurred within a space of a few heats, the second shutdown is a poor time to patch a sprung basic roof. Apparently, cooling cracks which developed during the first shutdown have not healed and are aggravated by the second shutdown. When a hole is opened for the installation of a patch, it tends to grow with brick around the perimeter of the hole falling in. There is little tendency for this to happen during patches which follow long operating periods. This tendency is not observed if roof suspension is used.

Basic roof patching—Basic roofs seldom require patching. Sometimes, through accident or unusual conditions which cause rapid wear of a local area, hot patching is necessary. Hot patching should be done only after an actual hole has developed in the roof. Then the minimum size patch which will close the hole should be made.

Extensive patching of basic roofs is seldom done except in cases of fully suspended roofs in those plants where major patching results in time saving as compared with complete rebuilding. In most cases, extensive patching is not economical.

Patching practices—The hot patching of basic roofs can be accomplished as quickly and with little more difficulty than patching of silica roofs.

Basic hot patches can be of suspended or sprung, keyed-in construction. Of the two, the use of a simple suspended arrangement saves time and brick.

In either case, when a patch is to be made, a hole about two feet wide is opened in the area to be patched. The hole is extended upward until about 4-in. thickness of the original roof is found. All transverse plates in the opened area are usually torn out but hold-down members are left undisturbed even if it is necessary to patch beneath them.

Suspended patches are usually made by laying about 1-in. bars on one foot centers across the hold down beams forming a grid over the hole. These bars are provided with a hook at one end to engage the upper hold-down member so that they cannot slide.

The tabs of the patch brick are bent up and supplied to the roof in this condition. Preformed "S" shaped wire hooks are used to engage the tabs of opposed pairs of brick. These are then hung on the bars, so that four rings hang from each bar. Several rings of brick can be installed at the same time.

In the event that a longitudinal hold-down member interferes and prevents the engagement of the brick tabs, an easy way to support these brick is to insert a welding rod under a slightly raised tab, then bend the tab down around the rod. This rod can extend over the two adjacent brick in its ring. Usually in installing

such brick, a brick is hung above the hold-down member leaving room for the insertion of the brick with welding rod attached. This is then inserted in the space provided.

If the patch brick do not fit the old roof rings exactly, as much as an inch can be made up by the insertion of ½ in. corrugated sheet irons in radial joints several courses of brick apart. If the needed closure is more than an inch, it is best to use different width keys or straight brick shapes to make up the necessary amount.

In installing patches, transverse plates need not be used although some plants include them. The elimination of transverse plates in the patch permits the patch rings to follow the pattern of the original roof without the use of specially sized patch brick.

When the initial opening in the roof has been filled with patch brick, it can be extended in either direction longitudinally if patching of these areas is necessary.

If, when the required patch has been nearly completed, it does not meet hole edges in a longitudinal direction, corrugated sheets in a few transverse joints can be utilized to effect the closure.

If more than one area is to be patched in the roof, these jobs can be done concurrently, if sufficient bricklaying personnel is available. This system, or some variation, achieves rapid hot patching of either sprung or suspended basic roofs.

Sprung, keyed-in patches of basic roofs are very similar to silica patches. The hole to be patched is opened as described earlier. When this is done, corrugated sheet iron is hung by any of various means so that it forms the desired hot face contour for the patch. The patch brick are then laid on this simulated center. The brick must fit the hole almost exactly and be keyed tight, but must not be driven so tight that the thinner sections of the original roof around the patch are disturbed. The driving key is normally a key brick with a ⅜ in. taper and should be driven approximately one to two in.

Wedge shapes are sometimes used in laying sprung, keyed-in patches so that fewer rings are needed to fill a given hole. However, if key brick were used in the original roof, this can cause complications.

Either suspended or sprung keyed-in patches are normally made with 9-in. brick. Patch brick of greater length would be wasteful. Six-in. patch brick are frequently used for suspended patches, and in one case, a trial is being made using 4½ in. side arch, tab brick so that the patch will be only 4½ in. thick. This use of thin patches promotes economy. However, it cannot be recommended for sprung, keyed-in patches because the stability of such a thin roof section is highly questionable.

Obviously in different plants great variation in patching procedures is possible. As in silica patching, individual plant conditions and preferences will have marked effects on patching practice. The methods described above merely illustrate that the patching of basic roofs need not be complex or overly difficult.

The end of basic roof campaigns—Basic roofs are usually taken off because of the failure of some other furnace part or because, through general debility of the entire system, furnace production is falling off. Frequently the roof itself could run further with only nominal repair.

When a furnace comes down for any reason, the basic roof should be inspected carefully and if possible, thickness measurements should be taken. The decision as to whether the roof should be left on depends on the desired length of run subsequent to the repair and previous experience.

In general, if roof thickness is less than four inches in large areas of the roof and the balance of the furnace will stand a long run, it is advisable to replace the roof. However, it should be remembered that a uniform 4-in. thick basic roof with good contour can last in service for more than 100 heats in some cases.

Basic roofs have occasionally been run to their ultimate end. When this was done, hot patching became necessary with increasing frequency in the last stages of the campaign. It was found that greater economy would have resulted if the furnace had been taken off earlier and the last hot patches not installed.

In view of this, it appears that when a basic roof reaches the point that numerous small patches are needed to prolong its life, it is time to replace the roof. This decision is invariably affected by local situations such as scheduling, demand for steel, or other factors. Occasionally, it is desirable to keep a furnace on despite some increase in costs. When this occurs, suspended roofs prove highly attractive as compared with sprung roofs. Suspended roofs can be kept on with less patching and with little danger of the collapse of the roof.

ECONOMIC EVALUATION OF BASIC ROOFS FOR OPEN HEARTH FURNACES

The economic success of basic roofs for open hearths is shown by their rapid and wide adoption in many different open hearth furnaces and operations. This result has been predicted for years but its wide acceptance has occurred within the last eighteen months.

The chief factors which changed and had major bearing on the economy of all-basic furnaces include:

1. Basic roofs have been made less expensive through the use of simpler designs and construction practices. In many cases, the installed cost of a basic roof has been less than twice that of the previously used silica roofs. Even the most elaborate initial installations seldom exceed three times the cost of silica roofs. Much of this cost is nonrepetitive. With roof life of from three to one to as much as five or six to one in favor of the basic roofs, the lower cost of basic roofs is assured.

2. Basic roofs have been "tailored" to fit the desired furnace operation so that virtually all of the roof brick are used.

3. Operating practices, in many cases, have become so severe that silica roofs will not withstand their effects.

These things produce notable savings in cost per ton of steel. This allows no credit for additional profits on steel produced by the all basic furnaces which could not be obtained from silica furnaces. Nor does it make allowance for the many intangible savings which accrue from the more assured, trouble free, longer runs of basic furnaces. Many plants with operating experience on substantial numbers of basic furnaces attest to these savings.

Basic refractories used in open hearth front and backwalls have not changed greatly in recent years. Wearing conditions remain substantially the same but are now more severe because of higher ambient temperatures and more slag splash if oxygen lances are used.

In the slag line areas and in the splash areas immediately above the slag line, the use of high magnesite-chrome ratio or chrome-free magnesite brick of high density normally yields best life. This is particularly true for oxygen lance furnaces in which high oxygen flow rates create severe splash conditions. Occasionally extensive exposure of walls to flush slags of high silica content might require higher chrome ore content refractories. However, in most cases the most severe exposure of front and back walls to slags comes from refining slags that are high in iron oxides and basic constituents. Predominantly magnesite refractories are more resistant to this type of slag.

Trials of internal-plated brick above the slag line in front and back walls have sometimes resulted in increase life, where severe spalling conditions existed at the wall faces. In some cases slag attack is more critical than spalling.

In such situations compromise between spalling resistance and slagging resistance is needed. This can be provided in part by variation in plating arrangements. Single internal plates or single internal plates without external edge plates provide small refractory faces but few joints for slag to attack. Much more work and experience with brick plating variations in front and backwalls is needed to determine the best arrangement for individual installations.

Compound walls made of high magnesia refractories in the lower sections where severe slagging is normally the chief cause of wear and chrome-magnesite and/or internal plated refractories in upper sections where spalling is pronounced may be an answer to some front and back wall refractory problems. Close observation of refractory wear can establish whether a definite wear pattern exists. If a regular wear pattern does occur, the use of compound walls frequently improves life.

One method of backwall maintenance which has been tried extensively in many shops and adopted in some is the pneumatic spraying of back walls with refractory materials between heats or during furnace operation. In some cases, front walls have also been sprayed.

Cost figures for spray maintenance of front and back walls will vary from shop to shop. Unquestionably, extensive spraying of back walls can eliminate hot repairs of these areas. The exact economics of this practice must be determined in each individual situation.

Improvement of basic refractories, particularly in the development of better magnesite-chrome refractories, has extended front and back wall life. However, in some cases, the severity of wearing conditions has increased faster than the improvements were made. In such cases, water continues as the ultimate front and back wall refractory. Increased use of water cooling in front and back walls bas been notable in the last two years.

It seems probable that the wear of front and back walls has been aggravated by closer control of fuel-air ratio so that reducing conditions may occasionally exist at the wall faces. Rapid elimination of carbon from the bath with resultant high carbon monoxide (CO) concentration in the furnace chamber could cause a like result. Further study of fuel-air ratio including bath carbon as a fuel, in relation to wear of refractories in front walls, back walls and many other furnace parts, is needed.

Many plants can improve their front and back wall life through changes in refractory practice but others have wear conditions which exceed the limits of any available refractories. In such cases, increased use of water cooling is the only practical answer at this time. Close study of individual conditions can show possible improvements.

Open Hearth Bottoms

Open hearth bottoms include a working hearth which encloses the bath of molten steel and slag and a sub-hearth which is not exposed to the bath except by accident. The working hearth portion of the bottom comprises a layer 12 to 18 in. thick. The sub-hearth extends from this layer downward.

The working hearth is in contact with boiling steel and slag much of the time. To resist the corrosive chemical attack, dense magnesia is required as a major refractory constituent. It has been said that the best bottom is that which includes the greatest weight of magnesia in each cubic foot. This is certainly true if silica and alumina impurities are kept low. Lime and iron oxide as impurities are not as deleterious.

The sub-hearth supports the working bottom and provides insurance against the loss of a heat of steel whenever the working hearth is completely eroded in a local area. Such erosion of the working hearth is not frequent but can occur often enough that the sub-hearth must be made of materials which will resist bath action and attack.

Years ago, many sub-hearths were made from burned chrome brick so that they could stand long periods of furnace shutdown without any danger of hydration. Some plants still use this practice. However, in the last twenty years, the upper portions of the sub-hearth have usually been made from dense, high magnesia content, burned magnesite brick to provide maximum insurance against rapid erosion if the sub-hearth should become exposed to the bath. Lower portions of the sub-hearth are frequently built from burned chrome-magnesite brick for economy.

Bottom design has changed gradually in recent years. Formerly, extremely thick bottoms were common. They included fireclay brick and even insulating brick at the base of the sub-hearth. It was learned that the insulating effect of such bottoms tended to make the working hearth mushy. Consequently, a trend toward thinner bottoms developed. This has continued to the extent that, now, new bottom pans are sometimes shaped to provide more nearly uniform bottom thickness at all locations. Preferred thickness is about 30 to 40 in.

With the trend toward thinner bottoms, another development of the brick structure of the sub-hearth incorporates inverted arches or semi-arches beneath the working hearth. These structures inhibit any tendency for the brick to float whenever the sub-hearth brickwork is exposed to the bath. Floating out of brick from stadia type bottoms has sometimes

been observed.

Inverted arch and semi-arch sub-hearths usually are made with a basic castable material against the pan forming the contour for the arch. The brick are then laid in 9-in. thick courses.

The working hearth of the bottom receives more attention than the sub-hearth. It must be repaired to some extent after every heat. With too great frequency, local areas are eroded deeply and require major repair. Initial installations of working hearths deserve highest quality refractories and the quality of materials used for repairs needs close scrutiny.

A few bottoms have been installed using high magnesia content burned magnesite brick to form the working bottoms as well as the sub-hearth section. These bottoms are believed to have performed satisfactorily although this practice has not been adopted widely.

Most working hearths are rammed with high magnesia content granular materials. The wide success of these bottoms indicates that this material is entirely satisfactory for most open hearth conditions. If a good ramming job is done, the installed density of burned brick can be approached. This requires extremely careful drying and early heating procedures to insure against any heaving, buckling or even explosions of the bottom as the result of too rapid elimination of water.

A successful innovation in the mixing of ramming materials for new bottoms provides accurate control of the moisture content of the ramming mix and delivers the mixed material to the ramming site without cumbersome conveyors. A pneumatic spray gun equipped for mixing slurries is used to mix the ramming material with water and convey it through a hose to the ramming site. Two or more guns can be used if ramming progresses at sufficient pace.

The mixers can be set up either on the pit side of the furnace or at some other convenient, out-of-the-way location. The hoses which convey the mixed material can go through the furnace tap hole or through any other convenient opening in the furnace walls. In this way, floor operations are unaffected by the mixing or conveying apparatus.

Some maintenance materials for open hearth bottoms have shown improvement similar to materials for new bottoms. Carefully sized mixtures of coarse, medium and fine magnesite grains have been developed for rapid hot patching of large holes in bottoms. When a hole has been cleaned thoroughly, and is filled with such material, sintering takes place rapidly in hot furnaces. Frequently if the tap hole must be piped or if the first drag of scrap must be brought to the furnace from the scrap yard, this time is sufficient to sinter the patch.

Sized magnesites such as those described above are also frequently used for cold resurfacing of bottoms. During a furnace rebuild, the material is spread over the area to be resurfaced in whatever thickness is necessary. By the time the furnace arrives at charging temperature, the new surface is sintered sufficiently to permit charging without additions of slag or other sintering aids.

Other bottom maintenance materials have not changed appreciably. Most tap hole piping materials remain as magnesites with admixtures of bonding agents. Some shops are trying the placement of tap hole materials by means of pneumatic guns. This requires specially grained sized magnesites with plasticizers and bonding agents. This practice, if carefully worked out for the individual case, could offer advantage in many shops. Its total worth is not completely evaluated.

Other bottom maintenance materials continue to be impure magnesitic materials and clinkered dolomite. Both of these materials have been used for many years. Both sinter more rapidly than higher purity magnesites but neither offers the resistance to chemical attack of higher magnesia content materials, assuming that equivalent density of patch is achieved.

Increased production rates and the use of a bath oxygen have tended to increase bath temperatures. In several instances, increased bottom wear has been observed. If this trend continues, a trend toward the use of higher quality bottom materials is expected. This will probably increase the use of the more pure magnesite materials.

In summary, higher quality bottom materials are currently available and will be needed increasingly in the future. As the need for better bottom maintenance materials develops, additional study and research should provide satisfactory products from currently available materials.

Open Hearth Furnace Ends

Open hearth furnace ends are defined for convenience, as ports, uptakes, slag pockets and fantail sections. In previous papers fantails have been considered separately, but because of the similarity of conditions in fantails and some slag pocket areas, they are considered here as a part of the furnace end.

Basic refractories for open hearth furnace ends have changed little in recent years. Suspended basic end constructions have continued to increase in use as has the total requirement for basic refractories.

Both chrome-magnesite and magnesite-chrome refractories have been widely used in all end sections. It is believed that individual operating conditions in different furnaces determine whether chrome-magnesite or magnesite-chrome brick perform better.

Construction of basic ends is more difficult than the construction of basic roofs. Basic ends, and particularly suspended sections, are expected to serve for long periods whether measured in number of heats or months. With this requirement, careful construction detail with regard to rigidity of steel structure and adequate expansion allowance is imperative.

Suspended nose sections have frequently been the shortest lived parts of basic ends. In some cases, life has been increased by strengthening the suspending steelwork. In others, increased expansion allowance has resulted in the same effect. However, excessive expansion allowance can cause excessive air infiltration. This causes poor fuel economy.

Summarizing the situation for basic refractories in open hearth furnace ends, magnesite-chrome or chrome-magnesite brick can be used dependent upon individual furnace conditions. Further study of expansion allowance is needed to provide sufficient room for brick or plate growth while keeping air infiltration figures low. Rigid suspension steelwork is needed in every case.

Open Hearth Regenerators

The use of basic refractories in open hearth regenera-

tors has not increased appreciably in America in the last two years.

Many basic brick have been tested in checker service. In general, the results of these trials have shown that virtually all chrome-magnesite, magnesite-chrome and most straight magnesite brick will stand up well at positions below the top courses of checker settings. None of these excel in the top courses. With severe operating conditions, the top two or three courses of open hearth basic checkers require replacement every few hundred heats. The balance of basic checker settings can have extremely long life.

Solid flue or basketweave arrangement is a must for reasonably successful basic checker installations. The use of some interlocking brick arrangement for the top two courses appears advantageous to inhibit tipping of brick during cleaning.

The most promising basic refractories for top courses are magnesite brick bonded so as to provide adequate strength but not brittleness. For the balance of basic checker settings, the least expensive basic refractory, with the exception of chrome brick, is usually satisfactory.

Some regenerator roofs have been built with basic refractories. Such installations have been fully suspended, flat arrangements. The brick that are used in open hearth main roofs offer best service.

The reason that basic checkers have not been used to a greater extent is that present regenerator designs do not lend themselves to full utilization of the basic refractories. Basic materials are more refractory than conventional checker materials and have much greater heat capacity. These attributes are attractive if they can be utilized. Current designs do not promote high checker temperatures so that a change from clay to basic checker material does not offer much improvement in air preheat. If regenerators were redesigned to include relatively small, high temperature sections ahead of the standard checker setting, basic materials would be warranted for such sections. Substantial increase of air preheat could be obtained in this way. Justification of basic checkers on the basis of life alone and without gain in heat exchange is doubtful.

Another factor which has tended to deemphasize the importance of air-preheat is the increased use of bath oxygen. Oxygen lances provide notable increase in the rate of heat input into the bath through faster burning of bath carbon. The heating obtained in this way can be so great that the importance of both fuel input rate and air-preheat is decreased.

In summary, basic brick for open hearth regenerators are available, but it appears that new designs of regenerator systems are needed to utilize the attributes of the higher cost basic brick.

ELECTRIC STEELMAKING FURNACES

The use of basic refractories in electric steelmaking furnaces continues to increase as more electric furnace units are installed and particularly as the number of large size (over 75-ton) furnaces increases. The increase in basic refractory usage results almost entirely from increases in steelmaking capacity rather than from any major changes in refractories practice as is the case with open hearth furnaces.

Preferred refractories for electric furnaces are identical with many products used in open hearths. In some cases, particular care is taken to apply different refractories in precise locations to meet the different wearing conditions of the local areas. This type of careful refractory application is seldom as closely followed in open hearth practice.

Bottoms for basic electric furnaces are very similar to open hearth bottoms. Inverted, dome-shaped subhearths of burned, high purity, magnesite brick are gaining popularity although stadia type bottoms, with brick laid flat and corbelled to form the desired contour, are still used in many places. The working surface of new electric furnace bottoms is made from high magnesia content ramming mixes in almost all cases. Installation of such bottoms is the same for electric furnaces and open hearths.

Bottom maintenance of electric furnaces is done with clinkered dolomites and with magnesite materials. The magnesites are used for the patching of major holes in the bottom while the dolomite is used for between-heat bottom maintenance as well as for the patching of minor holes.

Electric furnace sidewalls require more basic refractories than other furnace parts. The sidewalls should be considered as two areas, the lower sections, including the slag line and splash areas, where slag attack is the chief cause of refractory wear, and the upper sections where, particularly in top-charged furnaces, thermal spalling is the chief cause of wear.

The slag line and splash areas need basic refractories of high density and magnesia content to resist the chemical attack of hot slags which flow rapidly against the refractories. Furnaces in which the power input is exceptionally high have been known to shoot a stream of molten slag through an open door as far as 50 ft. The slag line and splash areas receive a constant battering of such streams of slag and metal. In some cases fused-cast basic refractories are needed to withstand the severe conditions.

If spray maintenance is practiced, the use of pneumatic guns which spray a slurry is preferred to those which spray dry materials with water added only at the spray nozzle.

The upper parts of sidewalls where slag splash is less destructive normally use chemically bonded, steel-plated chrome-magnesite, magnesite-chrome or, in some cases, chrome-free magnesite brick.

Magnesite-chrome brick are widely used in large furnaces. Some of these are equipped for door charging so that spalling conditions are not severe. With top-charged furnaces, it is frequently helpful to use a few courses of internally plated chrome-magnesite brick for the upper courses to combat the severe spalling conditions.

With many smaller electric furnaces internal-plated chrome-magnesite brick have excellent results for the entire sidewall above the slag line area.

Magnesite brick for sidewalls are usually internally plated. Such brick find application in some extremely hot furnaces where slag splash is apt to cover the entire sidewall. Variations of internal and external to single internal plates and/or elimination of external edge plates, sometimes help wall life. Such plating variation may also be used on magnesite-chrome refractories.

On occasion, the steel plates, both external and internal, have been observed to melt out leaving gaps in the sidewall with unsupported brick fingers sticking out toward the center of the furnace. If this occurs, the brick fingers are prone to spall away and the open joints are invitations to increased slag attack. One might think that complete elimination of the steel plates would be helpful, but experience has shown that brick with some plates give better life than unplated brick. In view of this, variation of brick plating arrangements offers the best chance for a compromise which yields good results in electric furnaces.

The reason for the melting out of plates that has been seen is probably the strongly reducing conditions which frequently occur in electric furnaces. Strongly reducing conditions combined with high temperatures cause reduction of the plate oxide and result in the running out of reduced, molten metal from the joints. Such conditions could penetrate deeply into the joints. They could also have major effect on the hot face portions of the brick material. The chrome ore component of the brick and any other iron containing constituents might be drastically affected. For these reasons, the use of magnesite-chrome brick with less and less chrome ore content and chrome-free magnesite refractories appears attractive.

In smaller furnaces where chrome-magnesite refractories yield best service as proved by comparative tests, high temperature, strongly reducing conditions are much less likely to occur. Further, more severe temperature fluctuation is apt to occur in these furnaces because of their smaller heat capacity. In this situation the greater spalling resistance of the chrome-magnesite refractory results in longer life.

Roofs of electric furnaces have had a few trials of basic refractories. Some complete basic roof installations have been made with moderate success. Ultimate failure of such roofs occurred in the center sections which were made up largely of rammed-in, high alumina refractories. In some cases more than one center section was installed with the basic portion of the roof being reused. Even so, the practice did not prove economical at the time the trials were made.

The recent success and rapid growth of sprung basic roofs on open hearths may stimulate further trials. However, improvement of high alumina refractories for electric furnace roofs and their expanding use at the expense of fireclay and silica materials has decreased the immediate need for electric furnace basic roofs.

Some plants have used small basic panels in fireclay or high alumina roofs confining the basic to those areas where "hot spots" have been observed to occur with greatest frequency. If such "hot spots" are repetitive and sufficiently troublesome, they can usually be corrected by the use of basic panels. In such cases, the use of a limited amount of basic roof refractories is warranted.

Another minor application of basic refractories in electric furnace roofs is in the outer rings adjacent to the skew. Basic brick in this location tend to stop roof wash from running down the basic sidewalls and eroding them. Where such installations are made, the basic brick should extend out from the roof skew beyond the wall face. When installed in this way the roof drip or wash drops from the edge of the basic ring into the furnace slag.

Summarizing the use of basic refractories in electric furnaces, bottom materials, both brick and grains, are very similar to the materials used in basic open hearths. The sidewalls of electric furnaces are the major basic refractory user of the electric furnace. Magnesite-chrome, chrome-magnesite and magnesite brick are all used in sidewalls. The selection of which should be used depends largely upon local conditions in the immediate area under consideration. Further improvement of electric furnace sidewall refractories is needed. It appears likely that this will come from the development of basic refractories which are more resistant to strongly reducing conditions at high temperatures while maintaining good resistance to spalling. Electric furnace roofs do not presently use many basic refractories. However, further trials and tests are expected.

BASIC REFRACTORIES FOR OXYGEN CONVERTERS

This paper would not be complete without mention of the rapid expansion in use of oxygen converters. Basic refractory linings for this major addition to steel production are still one of its major economic problems.

Relatively little experience has been gained on the new, increasingly larger vessels which have been built recently or are projected. Even the oldest oxygen converters were built during this decade.

To date there is no uniformity in the linings used even in the four or five oldest installations. Various mixtures of dolomite and tar; dolomite, magnesite and tar; straight magnesite and tar and burned magnesite brick are all currently used. Proponents of each lining material claim it to be successful and best. Yet all are searching avidly for improvement of lining life.

In this situation it is impossible to generalize on linings for oxygen converters with regard to good or poor materials or as to where further improvement of products is likely to be found.

In the United States, the brick most used to date have been tar-bonded mixtures of coarse calcined dolomite with calcined magnesite fines. The brick must be used shortly after manufacture or special precautions must be taken to prevent hydration of the dolomite which causes the brick to decrepitate. If hydration starts and progresses to some degree and the brick are used, lining life suffers. Further research on means to inhibit hydration of dolomite will probably solve such brick storage and shipment problems.

Despite the huge volumes of oxygen that are introduced into oxygen converters, the atmosphere which surrounds the refractory walls is frequently highly reducing because of the rapid evolution of carbon monoxide from the bath. This probably affects wear of the refractories as much as the other known conditions of refractory wear. These include mechanical abrasion of the scrap charge, chemical attack of the furnace slag and the thermal fluctuation which results from the cyclic nature of the operation. Further work is needed to develop basic refractories which resist reducing conditions well, not only for oxygen converters, but for open hearths, electric furnaces and many other industrial applications.

Much research work of this nature is in progress.

It is still too early to foretell the path this work will take or its outcome, but it can be expected that improved basic refractories for oxygen converter linings will be obtained.

SUMMARY OF FUTURE OUTLOOK

The future outlook for basic refractories is more than promising. Open hearth furnaces are currently going through a major change in refractories usage with basic refractories coming to a predominant position; electric furnace capacity is increasing with the emphasis on large furnaces which have become major consumers of basic materials. These and the introduction of basic lined oxygen converters as major tonnage steel producers all presage vastly increased demand for basic materials.

There is some pattern in the requirements of these various basic refractory consuming units. High purity and more dense calcined magnesites are in increasing demand. Comparatively the demand for chrome ore as a major basic refractory constituent is beginning to decrease. It should be stressed that this trend away from the use of chrome ore in basic refractories is not strong at this time.

Intermediate quality magnesites (in terms of magnesia content) formerly used for brick manufacture, are now becoming available for use in bottoms where relatively low quality magnesites have been used in recent years.

At this moment, new production from several high grade natural magnesite deposits has started or soon will. Sea-water or brine magnesite production is being expanded and up-graded. The availability of magnesites which will meet the requirements of the steel or other industries is assured.

With regard to chrome ores, most refractory materials have come from the Philippines in recent years. Southern Africa also has ample reserves of chrome ore. These reserves are being developed further to assure a long term supply.

Basic raw materials supplies and production facilities are being expanded and improved as fast or faster than the increasing demands of industry require them. Research toward still further improvement of basic products continues and such improvements will be developed.

The progress of western civilization depends upon the sum total of these many small accomplishments.

Discussion

PRESENTED BY

RICHARD G. PHELPS, Manager Steel Production, Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

MERVIN A. FAY, Manager, Basic Sales, General Refractories Co., Philadelphia, Pa.

F. C. McGOUGH, Superintendent, Fuel and Power, The Youngstown Sheet and Tube Co., East Chicago, Ind.

T. D. HESS, Superintendent, No. 1 Open Hearth, The Youngstown Sheet and Tube Co., East Chicago, Ind.

JOHN C. CAMPBELL, Open Hearth Metallurgist, Dominion Steel and Coal Co., Sydney, Nova Scotia

WILLIAM J. SCHARFENAKER, Chief Ceramic Engineer, National Steel Corp., Detroit, Mich.

Richard G. Phelps: It was mentioned that the basic roof should be held at the optimum temperature. What temperature do you propose as a minimum?

Mervin A. Fay: We would like to see the minimum temperature to which a basic roof might drop during charging kept as high as 2600 F if possible. In many cases, however, successful basic roofs are operating with the minimum roof temperature as low as 2200 to 2400 F.

F. C. McGough: As the result of the last steel strike, there were a number of basic furnaces with several hundred heats on their roofs that were shut down cold. What, in your opinion, will be the experience after these furnaces are relighted?

Mervin A. Fay: There is some experience on long shutdowns of a basic roof. A Canadian steel mill had a basic roof which was shut down for almost three months during the middle of its campaign. No appreciable difference in campaign life was found between this roof and that of subsequent basic roofs in the same plant. We do not expect any unusual difficulties when existing basic roofs are returned to service.

T. D. Hess: In starting up a new basic roof, do you have any numbers that compare to the ones we use for silica, 125 degrees per hour for four hours, 150 degrees per hour for four hours and then as fast as you can?

Mervin A. Fay: Basic brick will withstand faster heating than silica without damage. The fastest heat-up of a basic furnace about which we have heard was done by heating the furnace to red heat as fast as possible, then hot metal was charged and an oxygen lance was used. The first heat was tapped in about 15 hours from initial light up. However, we have been inclined to suggest the use of normal silica furnace heat up schedules particularly for initial basic roof installations to protect other furnace parts. As more experience is gained in each shop, faster safe heating up schedules can be developed.

John C. Campbell: I would like to ask Mr. Fay if he has any recommendations for a basic roof on a tilting furnace?

Mervin A. Fay: Mr. Campbell has more experience with basic roofs on tilting furnaces than anyone here. His company has the only one currently built on this continent. In my opinion a basic roof for a tilting furnace can be very successful if it is held down sufficiently well so that it cannot deform. If for some reason the arch is fairly flat I feel that the arch should also be suspended.

William J. Scharfenaker: You mentioned the possibility of eliminating the transverse plates and the likelihood of necessity for additional hold-downs. Do you know of someone who has successfully operated such a roof?

A man from a German steel works—incidentally a plant reported to be tapping 180-ton heats, running about 24 tons an hour which is a good production rate—was sorely puzzled. They are operating under basic roofs and regularly getting 800 heats, and they have

gone as high as 1200. He was sorely puzzled why ours are so short-lived compared to what he is used to.

I told him heats sometimes are not a full measure and pounds of brick used per ton of steel sometimes is a better measure, so I asked him if he had knowledge of the pounds of brick usage per ton on his furnaces, and he was not sure of himself, but came up with a conclusion that it was around 1½ lb of brick per ton of steel. This is far better than anything I know of in this country. We would appreciate if you would comment on the difference.

Mervin A. Fay: With regard to the possible elimination of transverse plates, we have had little actual experience to date. One such roof completed its run this year. It was improperly held down and as a result deformed, causing the end of its campaign. However, the brick were still thick enough for considerably more service had the contour of the arch been maintained.

From observation made of some basic roofs during the strike, there is some evidence that some greater wear may be occurring on the brick courses immediately adjacent to the transverse plates. On this basis there might be some advantage to the roofs from their removal. However, we feel that more hold-downs may be necessary to preserve the arch contour if no plates are used because the plates are effective stiffeners of the roof. We cannot calculate exactly how much additional holding down might be needed.

With regard to European basic furnaces, the one described is one of the most outstanding basic roof operations in Europe. In my knowledge, there are no other furnaces in operation in Europe which have similar records. I believe that to a large extent the good roof life results from particularly advantageous conditions for the basic roofs that are provided by the furnace port and furnace chamber designs.

The basic roof performance of three other European steel plants might be cited for comparison. All of these plants have furnaces of about 200-metric ton capacity and operate on hot metal practice with high firing and production rate. All of them approximate American open hearth practices. The roof life obtained on these furnaces is from about 200 to 350 heats and is very much in line with some American experience.

In view of these facts and the published information on most other European basic roof experience, we cannot see anything which indicates better general performance of basic roofs on European open hearths. ▲

AISE Utah and Colorado District Sections

Hotel Colorado — Glenwood Springs

June 24, 25, 26, 1960

FRIDAY, JUNE 24

Afternoon—REGISTRATION AND BARBECUE—

SATURDAY, JUNE 25

9:00 am—TECHNICAL SESSION—

Chairman: G. A. Jedenoff, General Superintendent, Geneva Works, Columbia-Geneva Steel Div., United States Steel Corp., Provo, Utah

"The Use of Castables in Repairing Blast Furnace Linings and the Incorporation of Radioisotopes in Such Repairs," by Eugene Frey, Practice Man, Blast Furnace Dept., Pueblo Plant, The Colorado Fuel and Iron Corp., Pueblo, Colo.

"Foundry Operations at Geneva Works," by J. W. Nielson, Superintendent-Foundry, Geneva Works, Columbia-Geneva Steel Div., United States Steel Corp., Provo, Utah

"Electrical Distribution Problems and Solutions in the Pueblo Plant," by George Wallis, Electrical Design Engineer, Pueblo Plant, The Colorado Fuel and Iron Corp., Pueblo, Colo.

"Routine Preventive Maintenance Program for Electrical Equipment in Steel Mills," by R. J. Coffey, General Foreman Electrical Operations, Geneva Works, Columbia-Geneva Steel Div., United States Steel Corp., Provo, Utah

12 Noon—LUNCHEON—
Hotel Pool Patio

2:00 pm—TECHNICAL SESSION

Chairman: Harold Gumma, Assistant Superintendent, Rolling Mills, Pueblo Plant, The Colorado Fuel and Iron Corp., Pueblo, Colo.

"Geneva Works Slabbing Mill Conversion," by W. H. Blomquist, Electrical Engineer, and H. V. Holdaway, General Foreman-Maintenance, Slab, Plate and Strip, Geneva Works, Columbia-Geneva Steel Div., United States Steel Corp., Provo, Utah

"Basic Roof for Open Hearth Furnaces," by C. M. Kay, Assistant Chairman Operating Committee—Open Hearth, United States Steel Corp., Pittsburgh, Pa.

"Ingot Defects—A Study of Origin and Effect," by Harley Hartman, Area Supervisor, Quality Control Dept., Pueblo Plant, The Colorado Fuel and Iron Corp., Pueblo, Colo.

"Basic Hot Blast Cupola"—a 16-mm motion picture produced by the German firm G.H.W.

5:00 pm—SOCIAL HOUR—
Frontier Bar

7:00 pm—STAG DINNER

Toastmaster: R. M. Weeks, General Foreman—Maintenance, Ironton Plant, Geneva Works, Columbia-Geneva Steel Div., United States Steel Corp., Provo, Utah

Speaker: H. A. "Harry" Stuhldreher, Assistant to the Vice President of Personnel, United States Steel Corp., Pittsburgh, Pa.

SUNDAY, JUNE 26

8:30 am—BREAKFAST COMMITTEE MEETINGS

These meetings are informal and items of common interest are discussed by those who wish to participate. The following general topics will be discussed: coke plant, blast furnace, open hearth, rolling mill and maintenance.

CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

No June Meeting

BUFFALO SECTION

No June Meeting

CANTON SECTION

Friday, August 5, 1960
Golf Party
Alliance Country Club, Alliance, Ohio

CHICAGO SECTION

Tuesday, June 7, 1960
Golf Party
Gary Country Club, Gary, Ind.

CLEVELAND SECTION

Thursday, July 14, 1960
Golf Party
Elyria Country Club
Route U. S. 20, West of Elyria, Ohio

COLORADO & UTAH SECTIONS

June 25 and 26, 1960
Two-Day Joint Meeting
Registration, June 24, 1960
Hotel Colorado, Glenwood Springs, Colo.

DETROIT SECTION

Tuesday, August 30, 1960
Golf Party
Meadowbrook Golf and Country Club, Detroit, Mich.

LOS ANGELES SECTION

Data Not Available

PHILADELPHIA SECTION

No June Meeting

PITTSBURGH SECTION

Monday, June 6, 1960
Golf Party
Edgewood Country Club, Pittsburgh, Pa.

ST. LOUIS SECTION

No June Meeting

SAN FRANCISCO SECTION

No June Meeting

YOUNGSTOWN SECTION

Thursday, June 23, 1960
Golf Party
Trumbull Country Club, Warren, Ohio

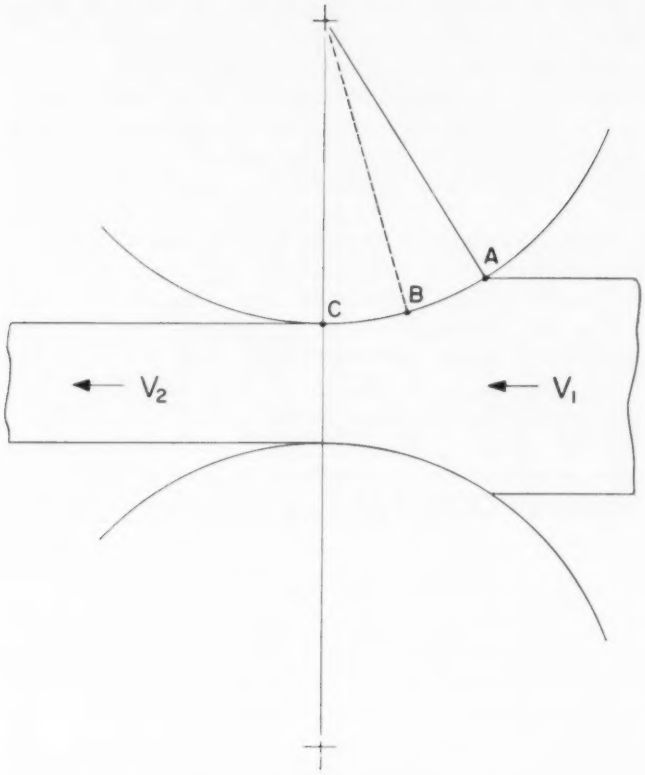


Figure 1 — Linear velocity of roll surface remains constant but that of bar varies.

Intelligent selection of ragging or knurling is necessary in preparing pass sequences . . . . if there is any doubt or possibility of trouble, controlled mill tests should be made . . . . ragging is often necessary and cannot be avoided.

Applications of Roll Ragging

by **HERMAN E. MULLER**
Superintendent, Roll Dept.,
Inland Steel Co.,
East Chicago, Ind.

RAGGING or knurling of rolls and the attendant effects cannot be intelligently discussed until the theory of rolling is touched upon. There is much material available on this subject and the appropriate references are appended. The many variables involved in the rolling process make exact theoretical approaches extremely difficult. The simple academic concept of hot rolling action will be briefly mentioned here. The primary interest in this respect is in the boundary region between the rolls and the bar.

Referring to Figure 1, the linear velocity of the roll at points A, B and C remains constant while the velocity of the bar changes from entering velocity V_1 to delivery velocity V_2.

In the classical concept it is assumed that the linear velocity of the bar changes in direct proportion to the elongation. Within the roll gap contact area it is theorized that the change of velocity is gradual. Elementary theory also assumes that plane sections remain plane. It is obvious that this cannot be so because of friction between rolls, bar plastic behavior and the spread phenomenon. It is postulated that a neutral point (B in Figure 1) or neutral zone exists in the contact arc where there is no slippage. Logically, in order to accomplish the transition of increase in bar velocity, the velocity on the entry side between Points A and B must be lower than the roll surface velocity. Investigators have studied test bars for the purpose of verifying this theory and for determining the pattern of metal flow in the roll gap with various results.

Figure 2 is an idealized flow pattern constructed from what is generally known regarding the mechanics of rolling. Between Points A and B there is a relative sliding of the roll in the direction of rolling. At B this relative sliding ceases. Between B and C the sliding reverses into the direction opposite rolling. It can be

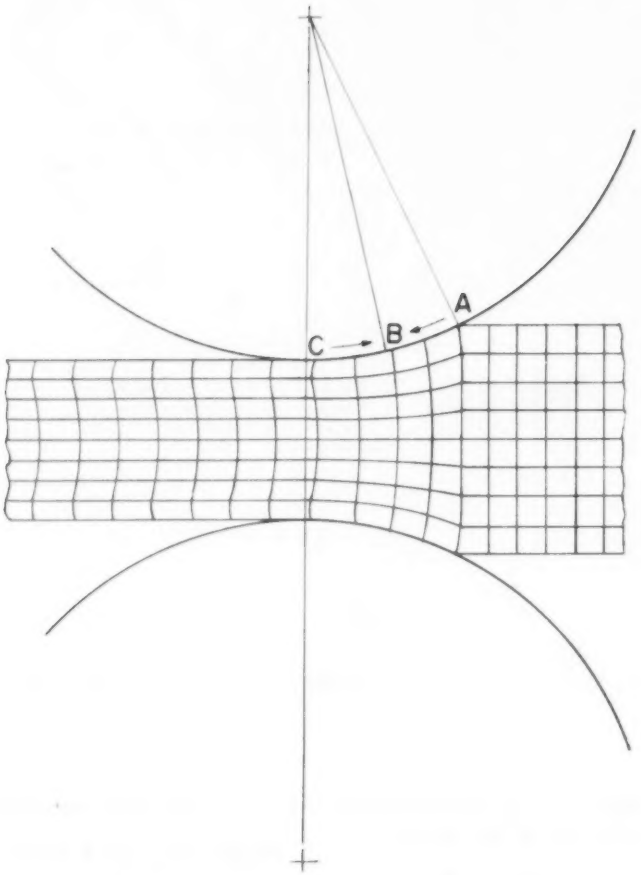
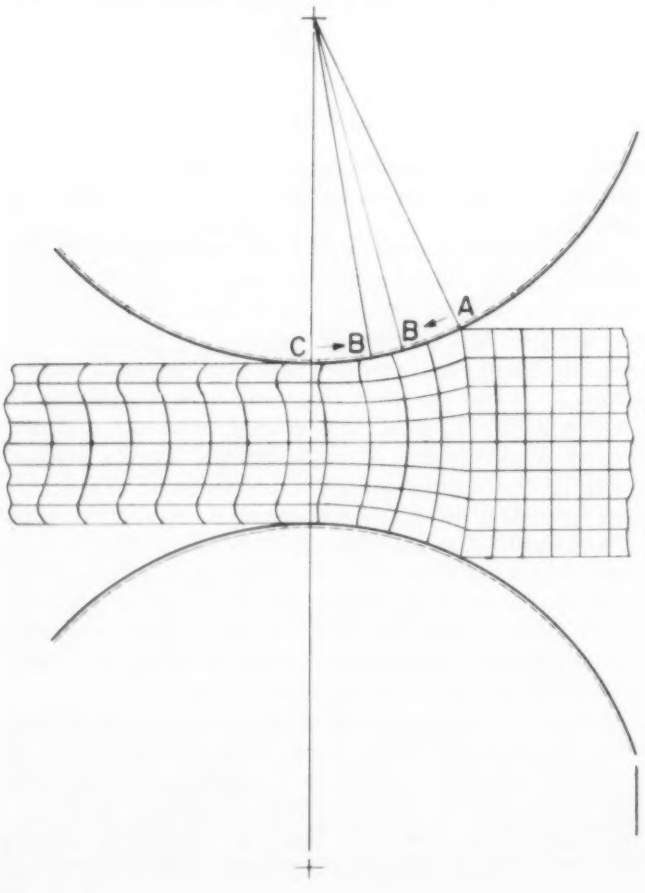


Figure 2 — Sketch shows the theoretical flow pattern for smooth rolls.

Figure 3 — Sketch shows flow pattern with knurled rolls.



proved that the heavier the draft the greater the tendency toward sliding. It is this sliding friction that is largely responsible for pass wear. (The arrows indicate forces acting on the bar.)

A dramatic opposite to rolling with smooth rolls is the performance of rolls knurled with a fine trapezoidal pattern; which is popular in the industry at the present time. See Figure 3. This type of knurling affords an inherently positive interlocking between the surface of the bar and the rolls, and is, therefore, excellent to study opposed to the plain roll situation. In this case the friction action of the surface of the roll is positive at A at entering side of the roll gap, tending to oppose the backward slip of the surface of the bar, but nevertheless powerless to prevent the relative backward displacement of the inner portion of the bar due to plasticity. As the now longer neutral zone (B - B′) is approached, compression forces penetrate toward the center of the bar causing a flow in the direction of rolling of the inner lamini, resulting in a straightening of the rearward curved flow pattern lines. Again, between B′ and C, the delivery side of the roll gap, a surface drag tends to reverse the curve of the flow pattern lines in the proximity of the surface of the bar. Because the surface of the bar cannot free itself, a relative displacement takes place in the outer layers. To some extent such events must take place whenever any type of ragging or knurling is used. The degree of such action is dependent on the spacing and depth of the knurling or ragging, the diameter of the rolls, the draft and resulting length of contact arc. The longer the contact arc for a given case, the greater the constraining force on the bar surface.

In order to illustrate this effect a plain and a knurled bar were rolled side by side on 21-in. diameter No. 1 stand roughing rolls of a 14-in. mill. Flats, 2 x 1¼-in., 0.22 per cent carbon mild steel, were drilled with 3/16-in. holes on ⅜-in. centers and plugged with brass rod. Test samples were heated in the furnace to approximately 1800 F and manually poked into the mill, jogging the mill so as to stall the bars in the mill. One test sample was rolled on a plain pass and another sample on a knurled pass with approximately 35 and 28 per cent draft respectively. Because the rolling was done without guides, certain undesirable distortions were unavoidable. The bars were cut and polished through the center axis so as to expose the flow pattern.

Figure 4 shows the contrasted flow patterns of smooth versus knurled rolls which tend to confirm the foregoing deduced theory. The piece rolled on the smooth pass showed the normal tendency toward relative backward flow of the center of the bar and a tendency to retard the outer layers in contact with the rolls at the delivery end of the pass. The bar rolled on the knurled pass shows a greater tendency toward backward flow at the pass entrance and more retarding at the pass exit, resulting in a more distorted flow pattern.

Figure 5 is a photograph of a 2 x 1¼-in. bar reduced to 29/32-in., with approximately 28 per cent draft, and rolled straight through on smooth rolls. The characteristic flow pattern is nicely illustrated.

In order to satisfy ourselves as to the surface effects of knurled ragging we carried out several tests on our 14 in. merchant mill during normal production. A set of No. 1 stand rolls was turned with two different types of

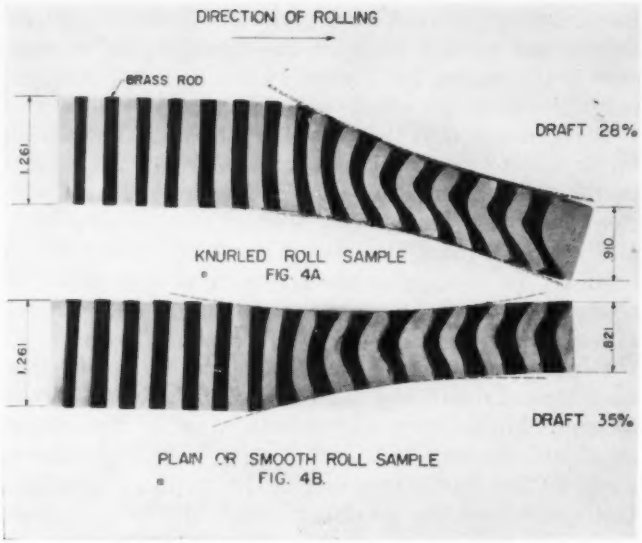


Figure 4 — Flow pattern is given for 2 x 1¼ in. flats of 0.22 per cent carbon steel bars cobbled in 21-in. diameter rolls. These were rolled from rest without guides. Mill was jogged by working rolls intermittently and bar temperature was approximately 1800 F.

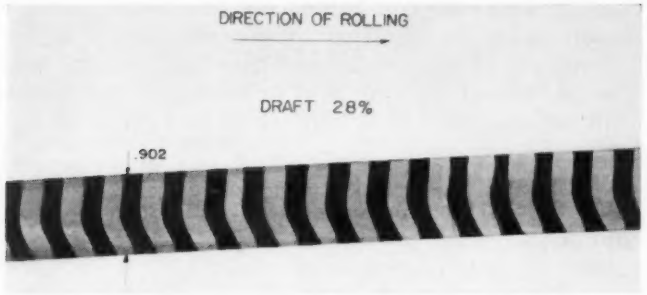


Figure 5 — Flow pattern for 0.22 per cent carbon, 2 x 1¼ in. flats, rolled in 21-in. diameter rolls at 69 fpm with bar temperature approximately 1800 F.

knurled ragging, i.e., the first a fine pattern illustrated by Figure 6; and the second a coarser and more open-angled type illustrated by Figure 7.

Billets of 5 x 5-in. structural grade being rolled into angles and subjected to various drafts were cobbled out of No. 1 and No. 2 stands. No. 1 stand is flat and No. 2 stand has an edging pass producing a square.

Figure 8 is a photomicrograph of a section in the direction of rolling of the finer type knurling at approximately 30 per cent draft.

Figure 9 is a photomicrograph of a billet rolled in No. 1 stand subjected to approximately 20 per cent draft using the coarser type knurling.

Contrasting these two it is evident that the coarser type knurling results in lower angularity and blunter peaks, a characteristic which minimizes the danger of lapping in subsequent passes.

Figure 10 shows the results of rolling with the finer type knurling, subjecting the bar to 45 per cent draft. Note the wipe in evidence at the higher draft. Whereas knurling makes possible extremely high drafts, the surface effect is undesirable. It was also thought worthwhile to compare the transverse section in stands No. 1 and No. 2 of the bar subjected to 45 per cent draft. Figure 11 shows the transverse section in No. 1 stand and Figure 12 shows the same section in No. 2 stand.

The longitudinal ribs have been closed in by the edging in No. 2 stand. Admittedly, this is an extremely high reduction; the 5 x 5-in. billet being rolled on the flat to 2¾-in.; the 3-in. square resulting by edging in No. 2 stand. There is, of course, the danger of also rolling these closely-spaced ribs into laps in later passes.

Figure 13 is a photomicrograph of a section in the direction of rolling in No. 2 stand. This has not altered appreciably from No. 1 stand, Figure 9.

None of these pictures indicate damage to the steel in the pass where the knurling was used, regardless of draft. It appears that the objectionable effects of knurling are developed in following passes due to the inability to roll in projections, by wiping or by local upsetting.

These tests lead to the conclusion that the knurled ragging results in: (1) A working of the surface by constriction. (2) Inhibition of elongation close to the bar surface, resulting in a deeper penetration of the rolling work, a substantially different result than from smooth rolls.

Thus far, no mention has been made of critical entering conditions. The facts regarding this are well known and have been covered by W. W. Trinks, Volume I. That ragging or knurling is often used to obtain a better bite and to avoid slippage at entry is obvious. Geometric

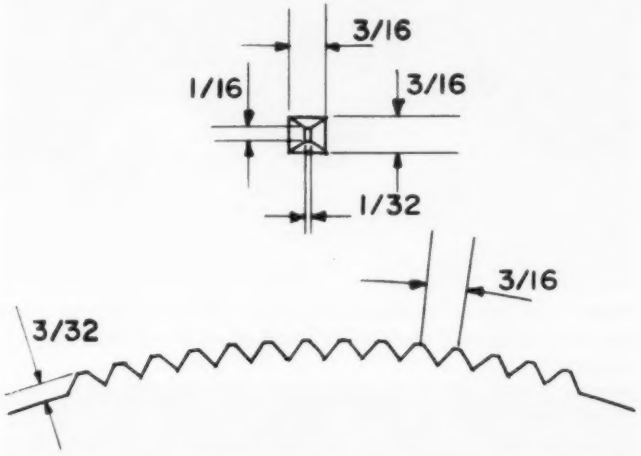


Figure 6 — Rollings were made with this fine type knurled ragging.

Figure 7 — Rollings were made with this coarser and more open-angled type knurling.

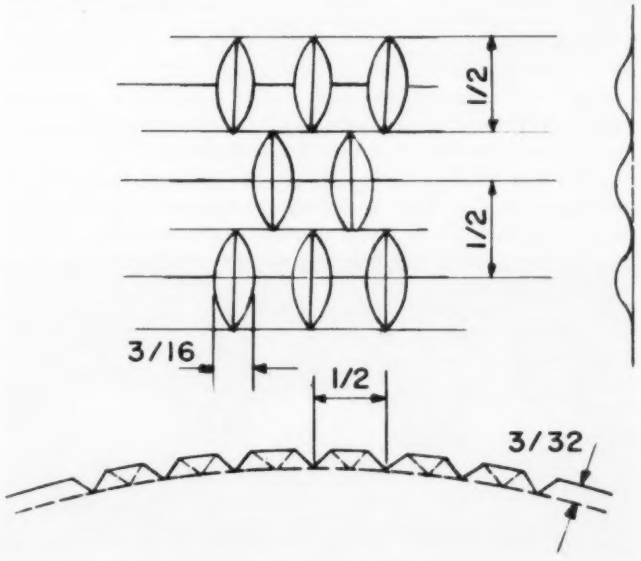


Figure 8 — Photomicrograph of rolling with knurling shown in Figure 6. (Magnification 7½×.)

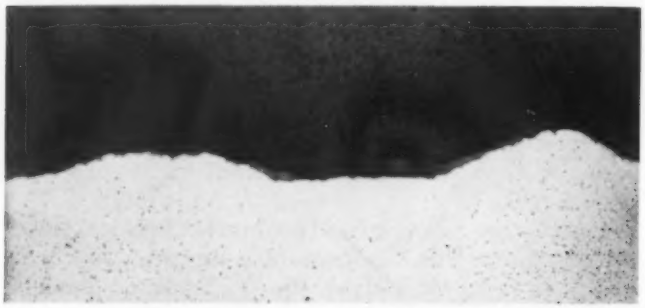


Figure 9 — Photomicrograph of rolling with knurling shown in Figure 7. (Magnification 7½×.)

Figure 10 — Photomicrograph shows effect of rolling with finer knurling of Figure 6 and draft of 45 per cent. (Magnification 7½×.)

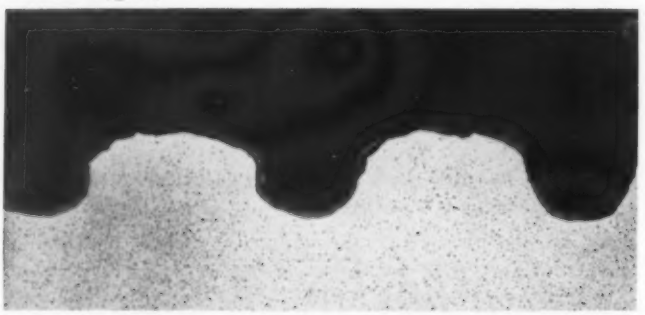
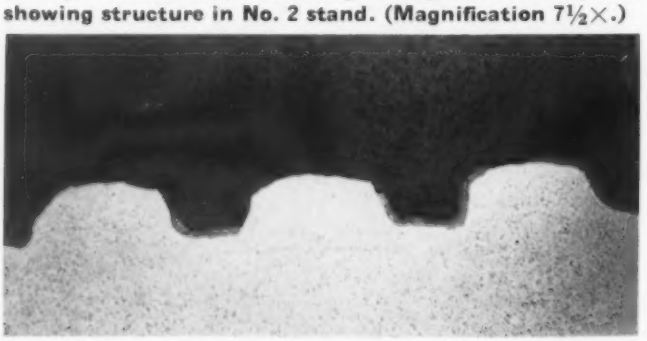


Figure 11 — Photomicrograph shows transverse section of rolling with fine type knurling of Figure 6 with photo showing structure in No. 1 stand. (Magnification 7½×.)

Figure 12 — Photomicrograph shows tansverse section of rolling with fine type knurling of Figure 6 with photo showing structure in No. 2 stand. (Magnification 7½×.)



relationships between bars and rolls influence the resulting bar surface pattern. For example, an extreme case is illustrated by Figure 14 where a hypothetical ragging is a straight-sided notch pattern.

It is obvious that the corners of the notch cannot fill up by direct vertical rolling forces. A notch moving in a path between Points A and B has a rocking motion relative to the bar. The relative angular motion between A and B makes for a first-class wiping circumstance. An absurd type of ragging pattern such as this should of course be avoided. In practice it is modified to incorporate sloping sides as illustrated by sketch, Figure 15.

It does not take too much imagination to see that regardless of depth and degree of slope there will always be some wiping from rolling with ragging. The extent to which this may be harmful or harmless depends entirely on the plastic behavior of the metal being rolled. If displacement can go on with limited wiping, not resulting in tearing or lapping, harmful effects can be minimized. Another variable to be considered is the steel grade being rolled. It is well known that certain types are extremely sensitive.

One phase of this particular work was to undertake a survey of industry practices with regard to knurling and ragging. This endeavor turned out successfully from a standpoint of co-operation by contemporaries in the industry. Much information and data has been received. The problem of digesting and presenting it in a useful form is formidable. It is impractical to publish all the information received.

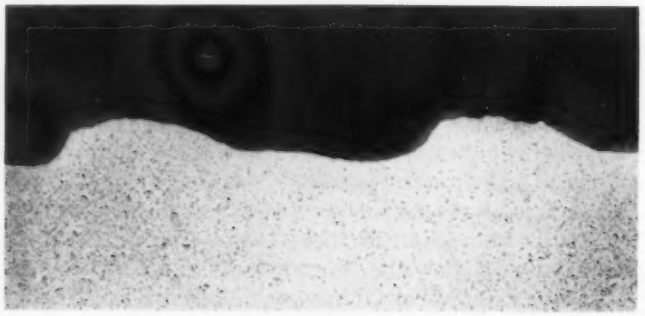
As a result of the survey these facts are outstanding:

1. Roll ragging or knurling is used mainly by non-alloy carbon steel producers. Alloy mills are very reluctant to apply ragging or knurling.
2. One particular form of knurling (the trapezoidal form) seems to be the most prevalent, occurring in 14 out of 42 blooming mills studied.
3. Reasons given for preference of this particular type of knurling are some of the same given for using other forms of knurling but also include reasons not mentioned as an advantage of ragging.

These are:

A. To prevent slippage.
B. To permit larger drafts.
C. To remove oxide.
D. To roll cleaner slabs; removing scabs.
E. To improve steel surface quality.
F. To permit smoother mill operation with less shock or chatter.

Figure 13 — Photomicrograph shows section of rolling with fine type knurling of Figure 6 with photo showing section in direction of rolling in No. 2 stand. (Magnification 7½×).



G. To minimize roll damage due to firecracking.
H. To optimize water cooling effects.

This particular type of knurling is the subject of a previous paper given by E. M. Benedict, superintendent, roll department, South Works, United States Steel Corp., and published in the 1955 Proceedings AISE, p. 239.

The general methods of producing the ragging or knurling patterns on rolls are:

1. Lathe and cam-operated tool.
2. Planing.
3. Milling.
4. Grinding.
5. Pneumatic chipping.
6. Pneumatic hammering.
7. Arc welding.
8. Turning circumferential grooves in a lathe.
9. Knurling using crush-type wheels in lathe.
10. Gas welding.

There may be other novel methods of forming either raised or depressed surfaces on rolls. There are as many types and methods as resources of the human mind can generate.

The results of the survey are tabulated for the typical types of knurling, ragging and applications in Figure 16.

This compilation is intended as a reference. No detailed dimensions are shown. An additional tabulation, Figure 17, illustrates a variety of the conventional forms of wave, corrugated or ribbed type ragging in use. In this exhibit the depth, spacing and dimensions are shown.

Figure 18 serves the same function for the knurled type patterns, illustrating spacing, height and angularity.

A most important, highly controversial, question regarding the application of ragging and knurling is: are there deleterious surface effects on the end product? The possibilities of defects generated by ragging or knurling carrying through to the finished product merit further comment and discussion. We refer to a paper by Mr. Mauer, Chief of Roll Designing, Society of Mining and Metallurgy of Rodange, Luxembourg, dated March 17, 1958. This paper was presented before a group of European roll designers in 1958. In this paper Mr. Mauer describes the steps and tests they undertook to evaluate the advantages or disadvantages of knurling blooming mill passes preceding a rail mill. After multiple tests they reached the conclusion that the quality of surface finish on the head and base of the rail was better with knurled ragging than with other types of ragging providing only certain early passes were knurled. As part of their test procedure they prepared photographs and photomicrographs of surface and cross sections of the bloom and finished rail samples. In order to establish a scientific basis of evaluation they compared only blooms rolled from the same ingot, one rolled with knurled and one with rib ragging. Although they concluded that the product resulting from knurled ragging was superior to that resulting from their raised-type rib ragging, there were still faint knurling spurs in evidence on the surface of the head and base considered unobjectionable. They concluded that one of the greatest advantages of the knurling is the freedom from surface

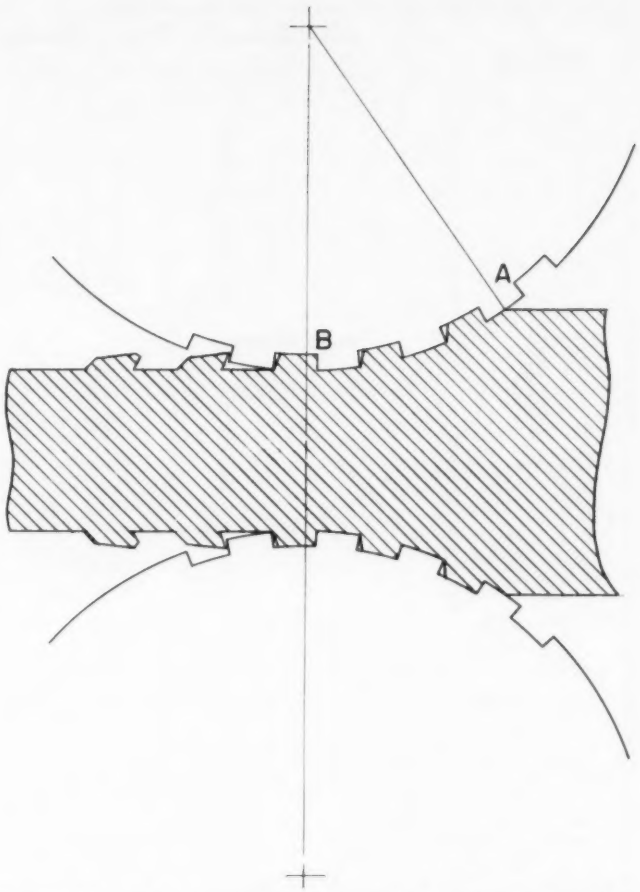
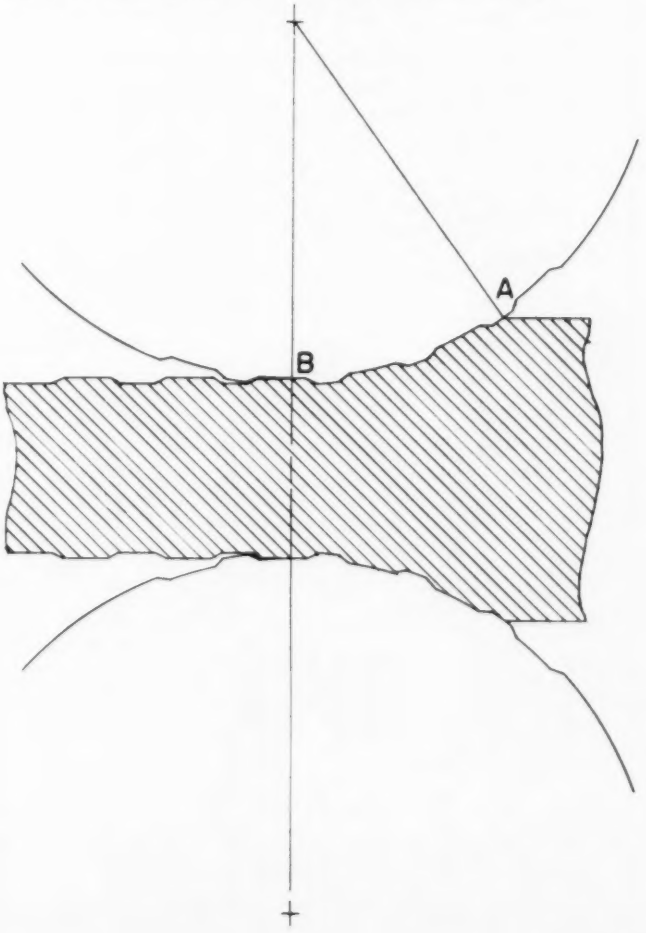


Figure 14 — This hypothetical knurling pattern cannot be used practically.

Figure 15 — Sloping sides are desirable in knurling.



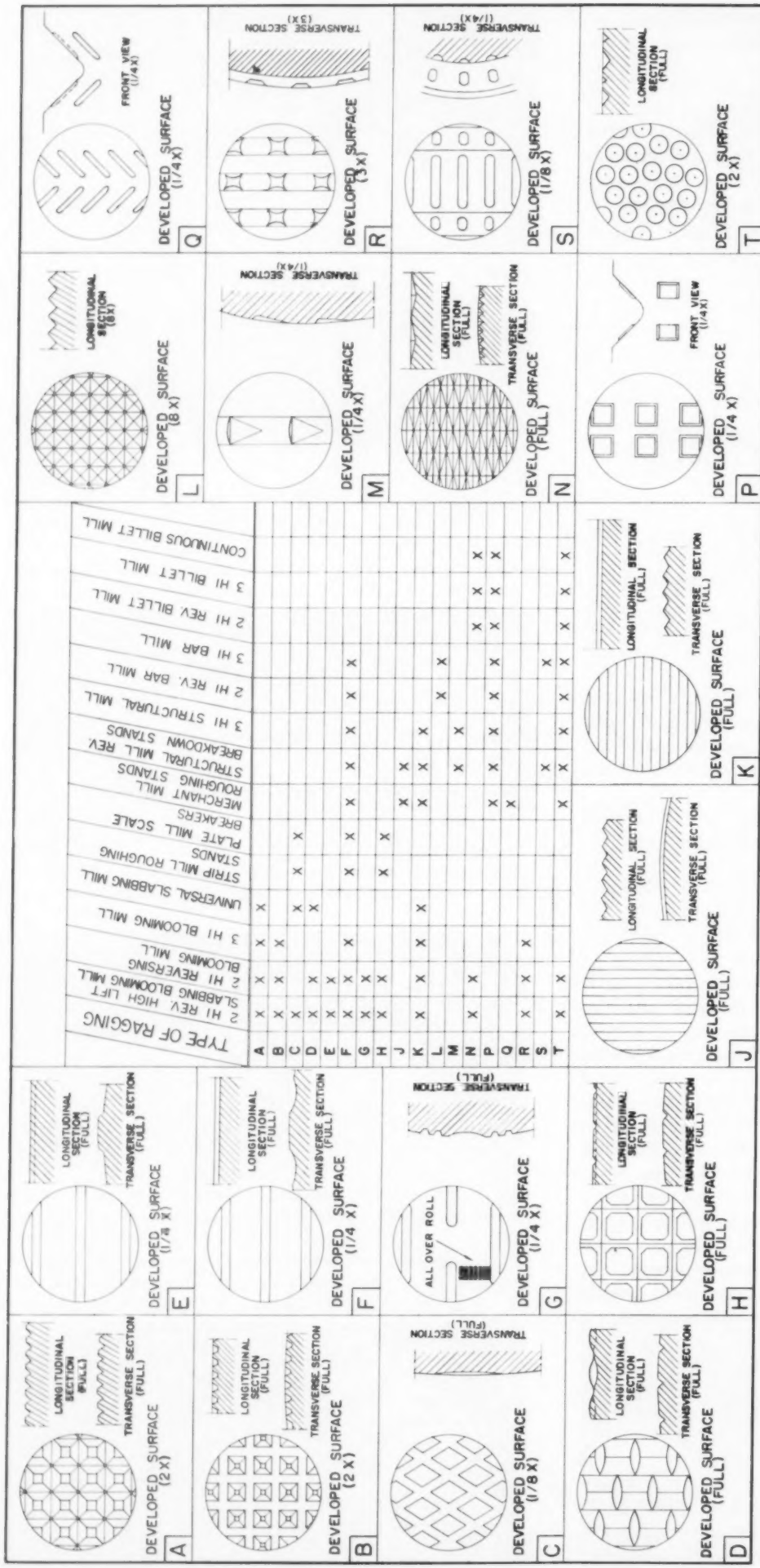

TYPE OF RAGGING
2 HI REV. HIGH LIFT SLABBING BLOOMING MILL
2 HI REVERSING BLOOMING MILL
3 HI BLOOMING MILL
UNIVERSAL SLABBING MILL
STRIP MILL ROUGHING STANDS
PLATE MILL SCALE BREAKERS
MERCHANT MILL ROUGHING STANDS
STRUCTURAL MILL REV. BREAKDOWN STANDS
3 HI STRUCTURAL MILL
2 HI REV. BAR MILL
3 HI BAR MILL
2 HI REV BILLET MILL
3 HI BILLET MILL
CONTINUOUS BILLET MILL
A B C D E F G H J K L M N P Q R S T
DEVELOPED SURFACE (2 X)
DEVELOPED SURFACE (1/8 X)
DEVELOPED SURFACE (1/4 X)
DEVELOPED SURFACE (8 X)
DEVELOPED SURFACE (3 X)
DEVELOPED SURFACE (FULL)
LONGITUDINAL SECTION (FULL)
TRANSVERSE SECTION (FULL)
LONGITUDINAL SECTION (8X)
TRANSVERSE SECTION (1/4X)
TRANSVERSE SECTION (3X)
FRONT VIEW (1/4X)
ALL OVER ROLL

Figure 16 — Various sketches show typical ragging or knurling patterns.

tears which they had experienced previously (no doubt resulting from their older raised-type ragging). It is probable that, had the finished product been other than rails, some product more critical, such as cold drawn rounds, the residual knurling spurs would have been unacceptable. This raises another question. To what extent can residual ragging or knurling indications be tolerated on the various finished products? Many mills roll a large variety of products through the same primary mills. For example, Inland Steel Co., rolls, on the 36-in. blooming mill, slabs and blooms which find their way into such diverse products as universal plates, structurals, cold drawn bars, reinforcing bars, tinplate, cold rolled sheets, hot rolled sheets, special shapes, and tube mill rounds. This mill, because of its small pitch diameter, 36-in., and extremely small pass diameter of 30 in. on the bullhead portion, has an acute slippage problem and requires ragging or knurling. The form of ragging on this mill is a rib ragging as shown in Figure 19.

At one time trapezoidal knurled ragging was tried on this mill with very satisfactory results as far as mill operations were concerned. However, due to the fact that we produced blooms which required setting aside for conditioning, we were immediately faced by the problem that the inspectors could not detect defects which were covered by the knurling pattern. We also suspected, with reason, that traces of knurling showed through on finished products. In addition, heavy plates produced on this mill for forging work were considered unsatisfactory by the trade.

An interesting case based on an experience with pepper ragging (produced by pneumatic hammering) is as follows:

$1\frac{3}{16}$ and $1\frac{1}{4}$-in. cold drawn rounds rolled on a 14-in. mill showed a line sliver condition as shown in Figure 20.

This condition was believed

to have originated from pepper ragging in No. 3 stand which was rolled in and lapped into a surface defect in subsequent stands.

Figure 21 shows the apparent progress of the defect in three samples along with the pass sequence used.

Figure 22 shows photomicrographs of the defects as found in samples taken from stands No. 4 and No. 6 and Figure 23 defects as found in the finished product. The disconcerting thing about this case is that in the past and thereafter no such difficulty was experienced on the same steel grade and section. It may be that at the time of the difficulties the ragging was a little too deep. Also, poor speed matching between No. 3 and No. 4 stands, which are closely-coupled may have resulted in slippage in No. 4 stand causing a wiping over of the little cones formed in No. 3 stand. To date this case is not resolved to the satisfaction of all concerned.

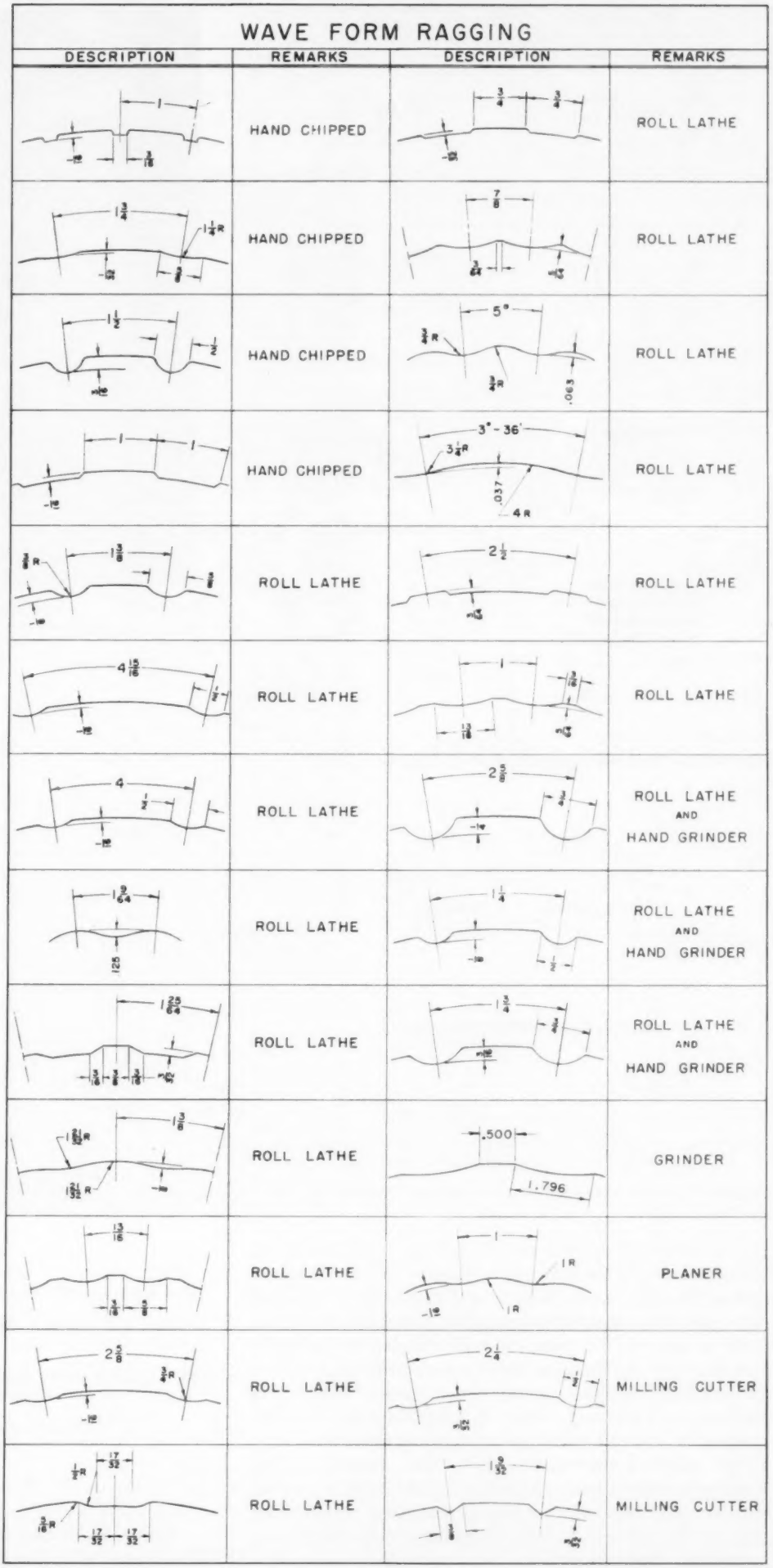
There are four primary mills at the Inland Steel Co., Indiana Harbor Works. Figures 24, 25 and 26, illustrating ragging related to rolls in all four mills. It is evident that our philosophy leans toward plain rolls on three of our blooming mills, namely: No. 2 46-in. blooming mill (Figure 24), a high lift mill, where slabs, blooms and beam blanks are rolled. Only the large edging pass is rib ragged; No. 3 46-in. blooming mill (Figure 25), a high-lift mill, where only slabs are rolled shows large edging pass is knurled. No. 4 universal slabbing mill (Figure 26) shows the horizontal rolls are plain.

The decisions in this regard are based on the following contentions:

1. The three larger blooming mills have roll diameters on the bullhead pass sufficient for good bite on most of the products rolled.

2. There is some product rolled on all of these mills that cannot be rolled without showing traces of the knurling which may be unacceptable, in the finished product.

Figure 17 — Sketch shows various types of wave ragging.



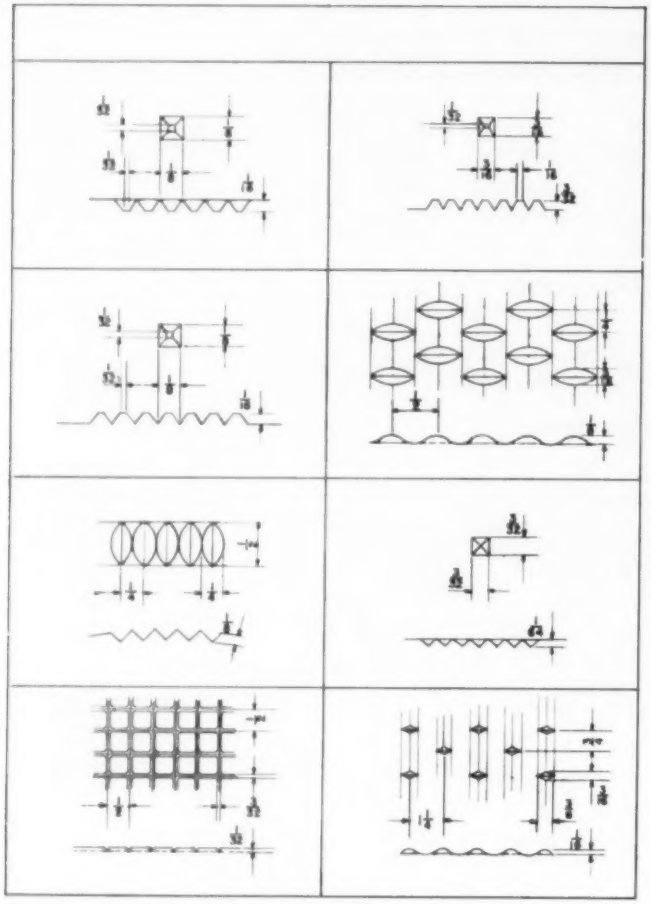


Figure 18 — Various types of knurled ragging.

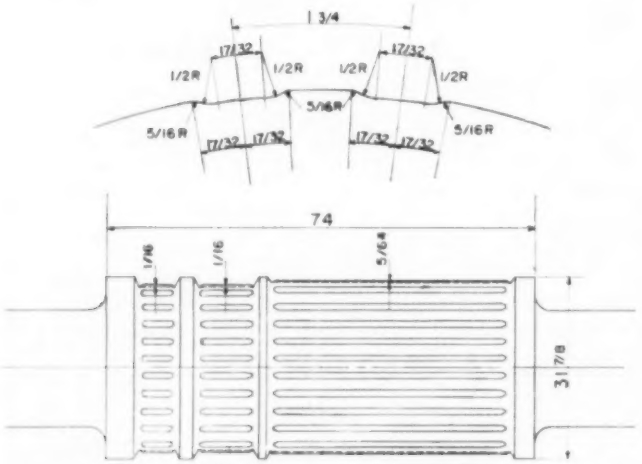


Figure 19 — The rib ragging is used on the No. 1, 36-in. blooming mill.

In addition to the wiping or lapping defects resulting from knurling there are other possible defects, such as closing in the longitudinal ribs by the flat and edge rolling process causing seams in the direction of rolling. Since a majority of primary mills are reversing mills, it is improbable that the knurling or ragging patterns will track or register in sequential passes. There is a mashing and lapping action from rolling the surface repeatedly with knurling indexing to various positions.

One must consider the fact that where 4-sided scarfing is used following the primary mill and reheating precedes the finishing mill, a large surface removal takes place to the extent that knurling-originated defects are completely removed.

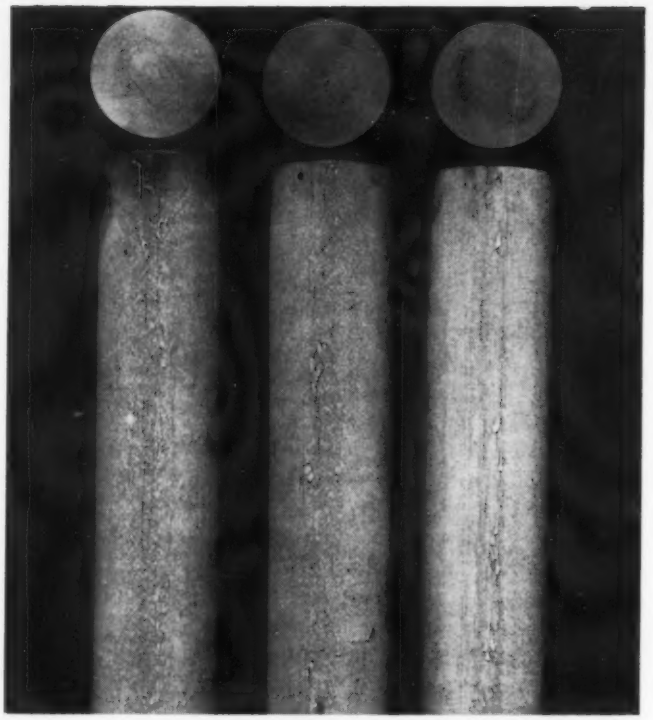


Figure 20 — These samples with pepper ragging showed a line sliver condition.

In conclusion, it must be stressed that not only is intelligent selection of ragging or knurling necessary in preparing pass sequences but when there is the slightest possibility of trouble, well controlled mill tests should be undertaken. Waiting for difficulties to appear can be expensive in production and claim loss.

The easy suggestion that the best ragging is no ragging is not tenable as a philosophy because we must live with the fact that it is often very necessary and cannot be avoided.

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Discussion

PRESENTED BY

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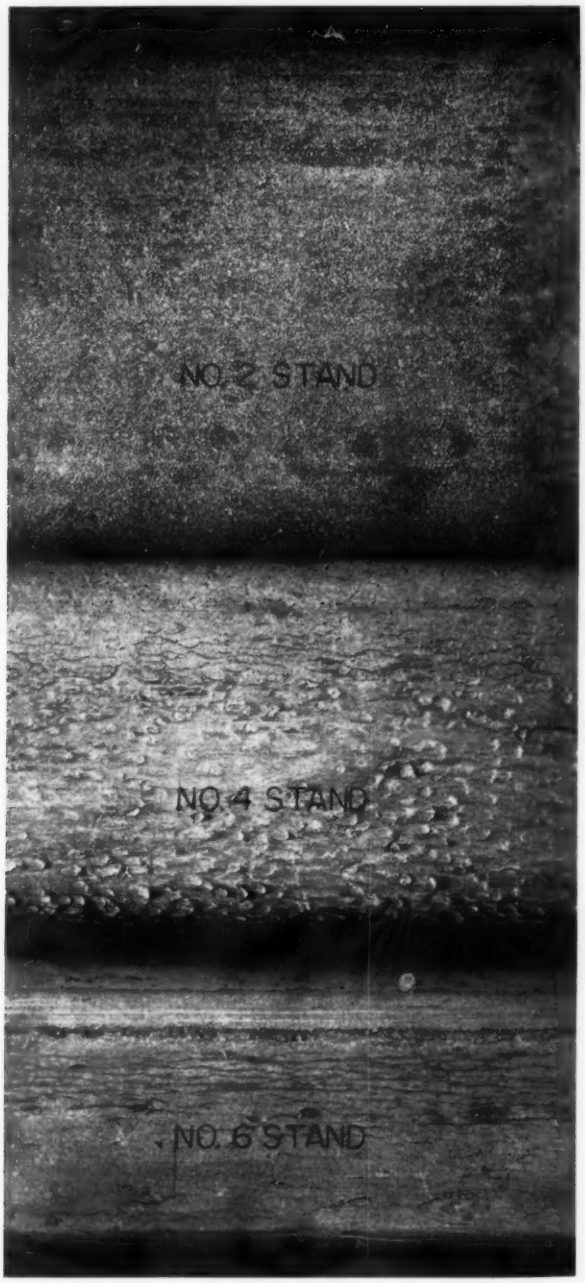
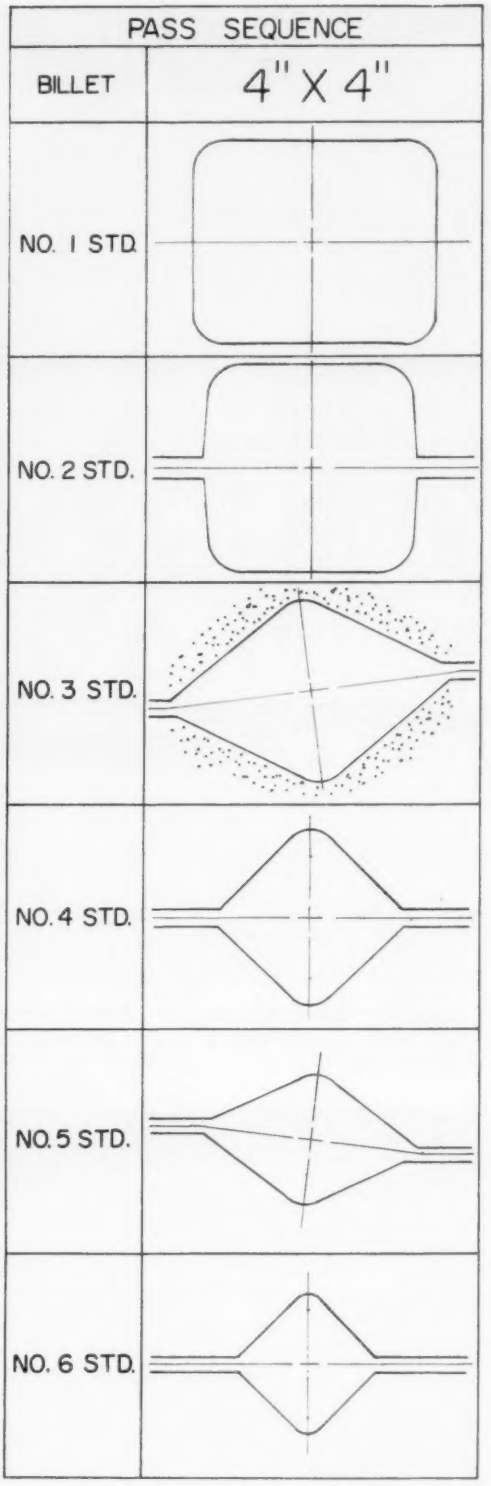
K. R. CASEY, Superintendent of Rolling, Kaiser Steel Corp., Fontana, Calif.

Harry W. Evans: Several years ago, mainly due to excessive mill vibration caused by ribbed ragging on

Figure 21 — It was believed that ragging resulted in a condition which was rolled in and lapped into a surface defect.





the bullhead, we changed over to the more recent wave type. We put it on the bullhead and in the wider edging passes.

As rolling progressed we discovered that the waves were squeezed together in subsequent passes on the bullhead and this produced on the side of the finished slab a series of saw teeth broken at intervals by the mark of the knurl. We did not like the appearance of these edges and quickly abandoned the use of wave ragging in the edge passes in favor of the older ribbed type. I note that Mr. Muller states that they use wave type in the passes of one mill and ribbed type in another. Why?

While it may be true that wave type ragging will more effectively break scale and produce a cleaner surface, it also produces a fine pattern on the slab that makes detection of cracks etc., less discernible than they would be on a plain surface. Has Inland had any trouble in this regard?

We encounter severe firecracking only occasionally, generally due to some accident on the mill. However, we have noted that the slight firecracking that does occur follows lines presented by the wave pattern cut around the roll by the lathe tool. For this reason we move the tool over $\frac{1}{8}$-in. at each dressing to avoid worsening any existing cracks. Has Inland experienced any trouble in this regard?

Herman E. Muller: We use the rib type ragging on

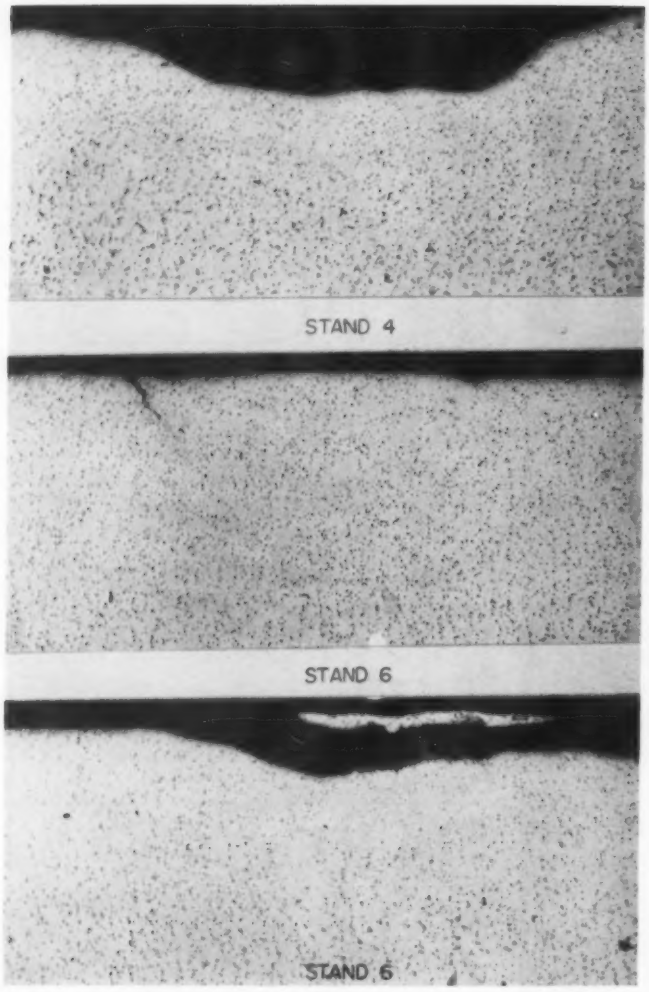


Figure 22 — Photomicrograph shows defects in samples taken from stands No. 4 and 6. (Magnification approximately 27×).

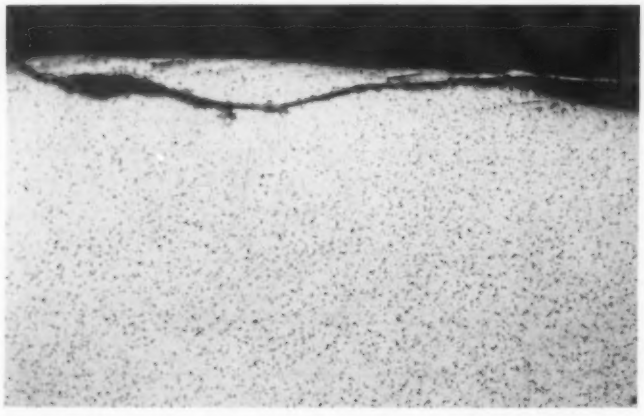
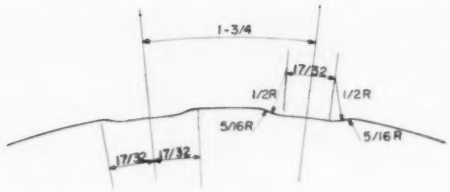


Figure 23 — Defect appeared in final finished product. (Magnification approximately 27×.)

our No. 2, 46-in. blooming mill which has large edging passes and we use the knurling pattern on No. 3, 46-in. blooming mill. No. 2 blooming mill is the mill preceding our structural mill which rolls blooms for billets; and blooms are rolled on the structural mill into billets in quality steel grades. We also practice double conversion, setting the steel out for inspection or conditioning and reheating.

In this instance in order to facilitate the finding of surface defects in inspecting these large blooms, we have stuck to rib ragging at the request of our quality con-



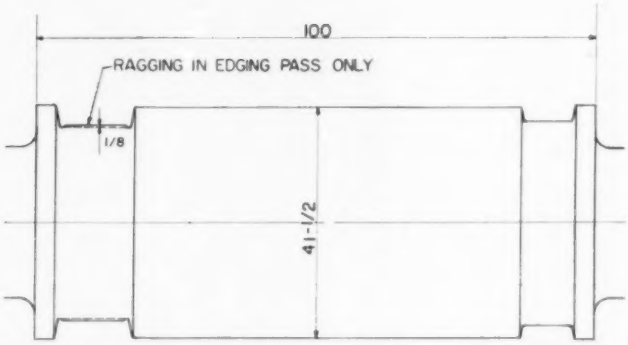
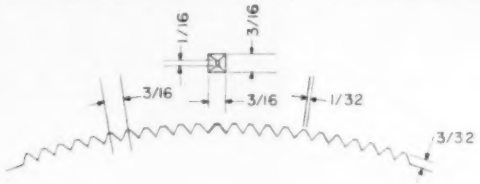


Figure 24 — Ragging used on No. 2, 46-in. blooming mill.



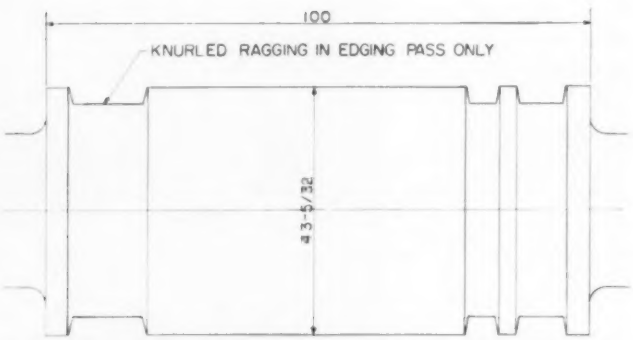
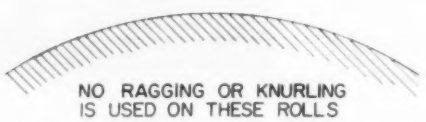


Figure 25 — Ragging used on No. 3, 36-in. blooming mill.

Figure 26 — No ragging is used on No. 4 universal slabbing mill.



trol department. On No. 3 blooming mill we have a different situation. There we roll slabs only. Knurling is preferred to the rib ragging because of its better bite and smoother action.

We do not use the knurled type ragging on the bullhead pass on any of our blooming mills. We use the rib type on No. 1 blooming mill because we have to for bite. I do not think we have had any complaints about the rib ragging at all. We realize that we would be better off from a bite standpoint with knurling. From a quality standpoint, we cannot use it.

On the question, "Have we discovered that firecracks tend to follow the tool marks," we have seen firecracks that followed tool marks on blooming mill rolls turned on a contour lathe. We have also seen it in rolls finished with block tools. We have seen it on knurling patterns. As a matter of fact, some of our people seem to think that the firecrack pattern did follow the circumferential knurling lines. Personally, I do not think so, and I do not think that aggravated the firecracking. I think the firecracking would have occurred regardless of tool marks or not. It is only logical to assume that the cracks start at focal points such as the knurling pattern because they are points of stress concentration. Cases of severe firecracking, the type that is generated very fast due to a sticker or hot spot in the roll, do not seem to be given direction by the knurling pattern. They do not follow tool marks because the stresses are more intense and erratic.

M. L. Weikert: Many of us have established good ragging practice after several trials on our own particular mills. The work done in this paper will be helpful in deciding on a type of ragging.

Ragging practice will vary from plant to plant and from mill to mill in the same plant. An example is a 40 by 82-in. universal slabbing mill and a 45 by 90-in. universal slabbing mill in the same plant.

The 40-in. mill uses ragged rolls and the 45-in. mill uses plain rolls. The 40-in. mill operated for years without ragging and ragging was added to break up scale. The 45-in. mill is fairly new and it may be that ragging will be thought necessary at some future date. In addition, the lift of the 40-in. mill will not permit edge rolling of ingots over 50 in. wide. The lift of the 45-in. mill will permit edge rolling of ingots up to 84 in. wide. The edge rolling is helpful for scale breaking.

A 54-in. blooming roll in the same plant, rolling principally slabs, has ragging in both bullhead and 12-in. groove. This ragging is necessary because of slippage.

Mr. Muller's paper has brought out what is happening to the surface of the steel at the arc of contact where it is locked to the roll with ragging and at the same time moving at varying speeds with relation to roll surface speed.

Herman E. Muller: Mr. Weikert brought out an important point on edge rolling that with universal slabbing mills we benefit from a lot of edging work which helps to remove scale.

Louis Moses: Everyone who has been responsible for ragging in any form, or on any mill, is fully aware of the complex ramifications presented. If ragging is not used at a given position the product can be damaged by jerky, lap producing, and chattering entry. At times the situations can be handled without roll ragging but the scale is not broken. When it is broken off in later passes the voids can cause damage. The thorough coverage of the paper shows the many types which can be selected when ragging is necessary, trials alone proving whether the type or relative severity is correctly applied. Serious consequences are present at every occasion, involving not only mill delays but the more costly steel itself and above all, the avoidance of product marring.

There are situations today which parallel, although in reduced degree, those of the 1910 to 1920 period when the respective production curves of bessemer and open hearth steels crossed each other. Rail and structural were particularly affected as both kinds of steel came from a common blooming mill. Deeply notched ragging was required to pull the "slippery" bessemer through the first heavily drafted passes. A characteristic of the composition of bessemer steel is that which allows the ragging embossings to be completely ironed out in later forming and finishing passes. However, if the next heat was open hearth steel, the same ragging would not iron out in later elongations, the marks persisting and scrapping the finished product. Reduced ragging efficiently pulled the "dry" or "stiffer" open hearth steel through roughing passes and met surface requirements. This ragging, however, would not pull the bessemer steel. Compromise, changes of ragging types, etc., were never satisfactory for either grade. Most obviously the open hearth shops or the converters could not be scheduled to suit the optimum ragging in the mills at any given time. This serious situation, as many old timers will recall, simply had to be lived with and worried through until the open hearth steels were accepted by the trade and predominated. The condition remains today with free machining, bessemer equivalent, bar grades which are reduced from ingot to bloom in the blooming mills with variances in drafting, the only noticeable effect between straight open hearth steel.

During several decades the volume production of large carbon steel angles never presented a single instance of ragging persisting into the product. On the first rolling of high tensile, low nickel content steel, the characteristics of the grade entered the picture because the customarily used ragging marred the finished angles. With both ordinary carbon and high tensile steels to be produced from the same rolls a solution was found. Comparatively shallow, parallel, axially arranged ragging grooves were cut in substitution of the previously used deep notching, working equally well with both steel grades. The ascribed reasoning is that deep notching was really not so much required as was an agency to break the furnace scale which otherwise piled up, retarding entry.

The optimum but varying temperatures for various grades of steel complicates the problem.

The subject will continually be with us.

K. R. Casey: If only the requirements of removing scale is a consideration, which type ragging, knurled or ribbed, do you recommend? I have in mind the strip mill scalebreaker and the roughing stand of a two stand plate mill. What is the difference in the effect on roll life between knurled and ribbed ragging?

Herman E. Muller: For removing scale, ribbed or knurled, I would venture the opinion that the knurl ragging is more efficient because the scale is broken up into finer particles than with the rib type. Of course, what I said in the paper still goes. It may be best from

that standpoint, it may be impossible to apply it.

As far as roll life is concerned, I can only rely on what I have read and have heard from other sources. We have not been in a position to evaluate knurling with respect to roll life. We have never tried it for a prolonged period on the major units where we could make such a comparison. Mr. Benedict, in his paper, I believe did mention something about roll life which was favorable toward the rolls with knurling. Mr. Mauer, in his European paper, also stated that, in his opinion, better roll life was achieved with knurling in the past because in European practice many mills have only still water supplies, re-circulating ponds, or insufficient cooling water. He thought the extended surface afforded by knurled ragging permitted better cooling and minimized firecracking. This condition is not as prevalent in this country. Many mills are situated close to good cool water supplies. ▲

Available Translations

As a service to readers of the *Iron and Steel Engineer* a list of translations from foreign articles is being printed intermittently. Articles selected for this listing will be those of primary interest to the American steel plant operator. The papers may be obtained from the British Iron and Steel Industry Translation Service, The Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W. 1, England. All correspondence concerning price, ordering, and so forth should be directed to that address.

918 PLATZER, F.: "New Methods of Plastic Deformation in the Working of Metals," *Berg- u. Huttenmann. Monatsh.*, 1957, Apr., pp. 115–125. A lecture. Reductions in area of 25–35 per cent are usual in modern rolling mills. If higher reductions, e.g., 80 per cent and more, could be employed, the rolling mills would be kept very much smaller and savings in production costs and capital outlay would be made. The author discusses the various principles of the high-reduction mills, such as the pilger mill, the krause mill, and the sendzimir planetary mill and describes in general terms a new type of planetary mill that he calls "Abollwalzwerk." The design principles of a number of modifications of this rolling mill are outlined. (Abstract JISI, 1958, Feb., p. 186.)

923 SCHWARZ, H.: "Torsion-resistant Box Girders in Steelworks Crane Construction," *Stahl u. Eisen*, 1957, Jan. 10, pp. 24–32. The author discusses in detail the merits of torsion-proof box girders for cranes used in iron and steel works and gives static calculations of the deflections under load. The deflections of a box girder may be larger than those of a conventional girder although the stresses in the latter may be very much higher than those in the box girder. The author quotes the advantages of the torsion-proof box-type girder, which are also stressed in the discussion. (Abstract JISI, 1957, July, 371.)

1123 HASIMOTO, H. A.: "Aerodynamic Design of the Open-hearth Furnace." IV—"Function of the Furnace Chamber," *Tetsu to Hagane*, 1957, June, pp. 628–632. Model studies to obtain the best chamber flow indicate: (a) the chamber spaces should be balanced in front of and behind the burner line, and thus the walls should be equidistant from it; (b) the shoulder angle should be 40 to 60 degrees, preferably 53 degrees; (c) the height of the main roof should be 37 to 55 per cent of the chamber width, preferably 46 per cent but less for large furnaces; and (d) the length should not exceed three chamber widths, while the bath length should be about 2.6 chamber widths or 3 bath widths. (Abstract JISI, 1958, Aug., p. 365b.)

1224 BAAKE, R., and ROSAHL, H.: "Experience with Multiple-strand Semi-continuous Casting," *Neue Hutte*, 1958, Dec., pp. 740–746. The characteristics and operational details of the large-scale, 3-strand continuous casting plant at Freital are described; an important feature is the control system, which is described in detail. (Abstract JISI, 1959, June, p. 178c.)

1259 WUSATOWSKI, Z.: "The Intensity of Deformation during Rolling," *Prace Inst. Hutn.* (Poland), 1958, (2), pp. 120–123 *Neue Hutte*, 1958, Aug., pp. 494–497. The author defines intensity of deformation and evolves formulas to calculate this factor, during rolling on a slip or nonslip plane. An example is given to the analysis of the rolling of a testpiece and the determination of the deformation intensity. The method described enables not only the vertical velocity as well as the deformation intensity to be correctly determined, but also the degree of deformation along the arc of contact. It was established that the main differences between the vertical velocities and intensities of deformation during rolling on slip and nonslip planes exist in the zone of retard. These differences in the dividing surface disappear, as in the zone of advance only inconsiderable values are apparent. (Abstract JISI, 1959, Apr., p. 403c.)

1384 NEUMANN, H.: "Knurling or Grooving of Rolls," *Neue Hutte*, 1959, Apr., pp. 244–246.

1381 GRASS, G.: "Heat Transfer of Rolled Finned Tubes," *Allgemeine Warmetechnik*, 1956, (5/6), pp. 104–108. It has been found that rolled tubes with their slight enlargement in surface area and their high fin efficiency generally reach the performance of the conventional type finned tubes with their large surface areas, though lower fine efficiency. Thus the superior strength at elevated temperatures and the smaller danger of fouling of rolled finned tubes are not incurred at the expense of any marked heat transfer or technical disadvantages. (Author's summary.)

Possibilities for A-C Cranes for Steel Mills

by H. A. ZOLLINGER, Materials Handling Engineer,
Industrial Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

In new installations where d-c power is not currently available it is expected that a-c cranes will become a standard . . . . factors are better crane life, lower maintenance and power savings . . . . a-c crane motors should be selected at about 15 per cent higher horsepower ratings than if d-c were used.

THE heavy duty a-c crane is up to the steel mill standards and can be applied on many applications where only constant voltage d-c cranes are used today. Using a-c cranes in various locations is warranted by the cost saving in power conversion equipment, in distribution of power, in electrical maintenance, and in mechanical maintenance, without sacrificing performance or reliability.

This paper discusses the advantages in using a-c cranes, provides a method of selecting motor horsepower and recommends practices that will avoid possible pitfalls.

There is increased interest in this subject. For example, one large steel company has established the practice of considering a-c for all new cranes to be purchased.

The well established heavy duty a-c crane control and the new ones are all different from the a-c crane controls of 10 and 20 years ago in two important respects. First, contactors have been replaced by static devices, and second, speed control is provided at all loads. By replacing contactors with static devices, two large advantages arise. Maintenance of control components has been virtually eliminated and the hoist motor is protected against transient currents associated with the closing of primary and secondary contactors. With good speed control, the lifts can be made quickly and safely. Along with these important improvements, many other important features are found. To mention a few, reduced mechanical maintenance, motor braking, torque limit, and elimination of most power resistor wiring.

Now consider the hoist horsepower required to do a given job. In most cases the duty of the crane is to move a variety of loads with the same hook. The average load for each crane may vary but can generally be summarized by approximately ½ rated load. This average varies because some cranes have two hoists, a main and an auxiliary, while others only have one, and also because the majority of loads handled are either near the rating of the crane or only a small fraction of the rating.

The difference in operation between a crane with one hoist versus one having two hoists can be seen from the following:

	Main hoist, tons	*Auxiliary hoist, tons*
Crane A	50	15
Crane B	30	15
Crane C	100	25

For cranes A, B and C, any load up to or slightly greater than the auxiliary hoist capacity would be handled by the auxiliary hoist. This leaves only the heavier lifts for the main hoist. For crane A, probably most of the lifting will be 25 ton and above rather than between 15 and 25 tons thereby showing greater than ½ load for an average lift. On crane B all lifts on the main hoist will be ½ load or above and on crane C, probably the average lifts on the main hook will equal ½ load. If these cranes are typical then on 2-hoist cranes the average lift will exceed ½ load and for single hook crane they will be equal or be a little less than ½ load.

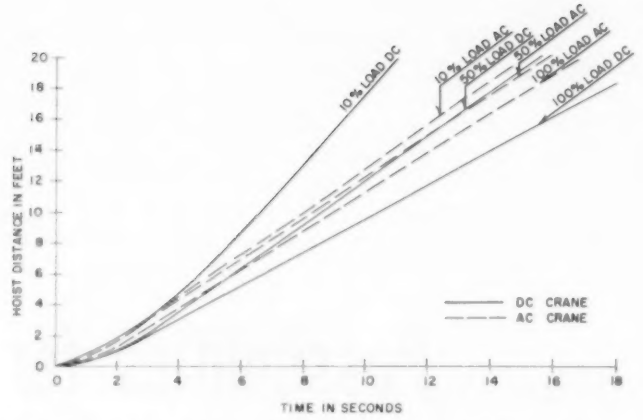


Figure 1 — Chart gives time-distance curves for d-c crane and a-c crane geared to give about 15 per cent higher full-load speed. With this ratio, performance is about equal with both types of cranes at full load.

The above information verifies the use of ½ full load for average load on comparing production of a d-c crane and of an a-c crane. To obtain equal production, the increased no load performance of the d-c crane must be off-set by the increased full load performance of the a-c crane.

HOIST DRIVE

Calculations have been made to compare the time-distance relationship of a typical a-c and a typical d-c hoist. These calculations were made at 10 per cent load, 50 per cent load and 100 per cent load. The time-distance plot was made because this is related to production.

Figure 1 shows this time-distance curve for a d-c crane (solid lines) and an a-c crane (dashed lines) with the a-c crane geared for 15 per cent higher full load speed than the d-c. This 15 per cent higher speed has been established by cut and try methods to provide equal performance at ½ load and as much increased production at full load on the a-c as is lost at light load. Other values of per cent increased in rated hoist speed are given in Table I.

In calculating the required horsepower for an a-c hoist, using the AISE Crane Specification No. 6 horse power formula, the following example, would be typical: (A 20-ton crane, d-c full load speed 65 fpm, 2500 lb hook block, 4-part line, double reduction.)

$$\text{Hp}_{d-c}\ (\tfrac{1}{2}\text{-hr}) = \frac{(40{,}000 + 2500) \times 65}{33{,}000 \times 0.87}$$

$$= 96 \text{ hp required}$$

$$\text{Hp}_{a-c}\ (1\text{-hr.})\ \frac{(40{,}000 + 2500)\ 65 \times 1.15}{33{,}000 \times 0.87} = 111 \text{ hp required}$$

Table I
Increase in Hoist Speed at Rated Load for A-C Cranes to Equal D-C Cranes Performance at Various Average Loads

Average load, per cent	Increase in rated hoist speed, per cent
100	0
50	15
33	20
10	40

For the d-c drive, 96 hp is required so a 100-hp, ½-hr rated, series-wound, totally-enclosed, 612 mill motor would be selected and for the a-c drive, 111 hp is required so a 125-hp totally enclosed crane and hoist, wound-rotor motor would be selected. The d-c crane would be geared to 65 fpm at full load and the a-c crane would be geared to 65 × 1.15 or 75 fpm at full load. This increased speed will not present a problem in controlling the hook because the a-c crane can operate at considerably lower speed on the first point than can the d-c crane. (See Figure 2).

Figure 2 shows the full speed points and the first speed points in each direction of the two cranes in the above example. The d-c crane is shown in the solid lines and the a-c crane shown in dashed lines.

In selecting an a-c hoist motor for heavy duty steel mill service, the use of a 1-hr rated, 75 C rise crane and hoist wound-rotor motor is recommended instead of the standard ½-hr rated totally-enclosed motor. This selection provides an a-c motor that can take the same crane duty as the d-c motor.

There are a few cranes that have their speeds selected by their light load production. This relatively rare type is found where a process cannot be started until the empty hook is moved a considerable distance. For these cranes Table I shows that a factor of 1.4 should be substituted for the 1.15 factor in calculating motor horsepower and the full load speed would correspondingly be increased by 40 per cent to provide equivalent performance at light load.

Another way to handle the desired increased speed at no load is to direct couple a hoist type squirrel cage motor to the wound-rotor motor. This small squirrel cage motor operates only at no load and runs the empty hook up and down at two to three times full load speed. This motor typically requires only one-fifth the horsepower of the main hoist and has a synchronous speed of 1800 rpm. The main hoist motor rpm at full load is selected to get the desired no load speed. The main

Figure 2 — The a-c crane can operate at lower speeds on the first point than the d-c crane.

hoist motor accelerates the drive to full speed and the small motor accelerates the drive, up to the no load speed. This arrangement then permits the use of a main motor equal in hp to the d-c motor.

TROLLEY AND BRIDGE DRIVES

The trolley and bridge drives in most cases are as important as the hoist in obtaining the desired production. To help evaluate their performance, the time-distance plot is used to determine equal production. Figure 3 shows typical performance for a trolley drive for both an a-c and a d-c crane and Figure 4 shows typical performance for a bridge drive. These have been made for maximum acceleration with full load and again with 15 per cent more horsepower on the a-c drives. Note that Table I only applies to hoists and not to trolley and bridge drives. The 15 per cent here is for any average load. As can be seen, the performance is equal or slightly in favor of the a-c drive.

The no load performance was checked and found to be in agreement with the results of the full load curves.

Thus the horsepower for a trolley or bridge by the AISE method would be as follows:

Example: (Load + Trolley = 34.25 tons, Load + Trolley + Bridge = 101.25 tons, 175 fpm trolley, 440-fpm bridge, acceleration is 1.5 ft per sec, trolley service factor is 1.5, bridge service factor is 1.4.)

$$\text{Trolley } hp_{d-c} = K_a \times 34.25 \text{ tons} \times 175 \text{ fpm} \times \text{service factor}$$

$$hp_{d-c} = 0.00117 \times 34.25 \times 175 \times 1.5$$

$$= 10 \text{ hp (1-hr) or } 13.3 \text{ hp } (\tfrac{1}{2} \text{ hr})$$

Use 13 hp ½-hr 603

$$\text{Trolley } hp_{a-c} = 0.00117 \times 34.25 \times 175 \times 1.5 \times 1.15$$

$$hp_{a-c} = 11.5 \text{ hp (1-hr) or } 15.3 \text{ hp } (\tfrac{1}{2}\text{-hr})$$

Use 15 hp, ½-hr rated, CIP

Both trolley drives are geared for 175 fpm at free running torque.

$$\text{Bridge } hp_{d-c} = K_a \times 101.25 \text{ tons} \times 440 \text{ fpm} \times \text{service factor}$$

$$hp_{d-c} = 0.0017 \times 101.25 \times 444 \times 1.4$$

$$73 = \text{hp (1-hr) or } 97 \text{ hp } (\tfrac{1}{2}\text{-hr})$$

Use 100 hp, ½-hr, 612

$$\text{Bridge } hp_{a-c} = 0.00117 \times 101.25 \times 440 \times 1.4 \times 1.15$$

$$hp_{a-c} = 84 \text{ hp (1-hr) or } 112 \text{ hp } (\tfrac{1}{2}\text{-hr})$$

Use 125 hp, ½-hr rated, CIP

Both bridges would be geared for 440 fpm at free running torque.

The 15 per cent more horsepower has been added to the a-c crane to obtain high acceleration at low speed and the rated speed of both the a-c and d-c drives should be kept the same.

Figure 5 shows the full speed and plugging speed-torque curves for a typical bridge drive for both an

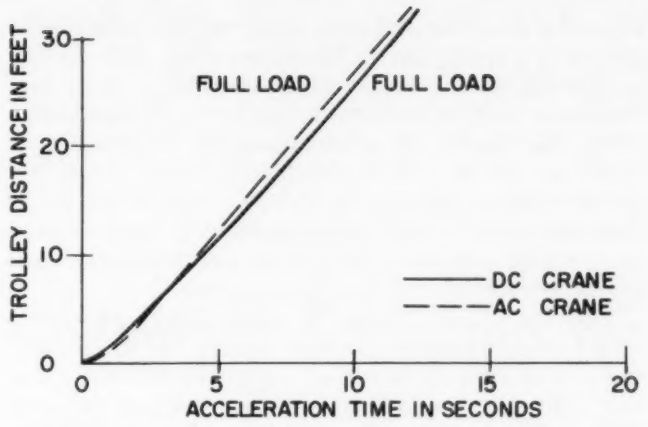


Figure 3 — Typical performance for a-c and d-c crane trolley drives.

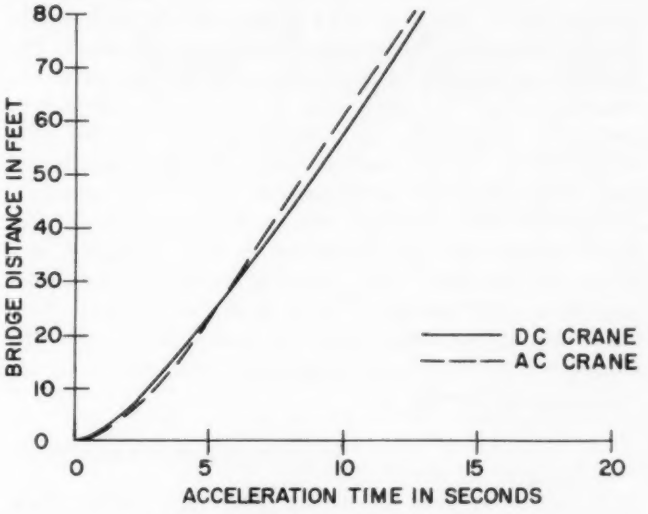
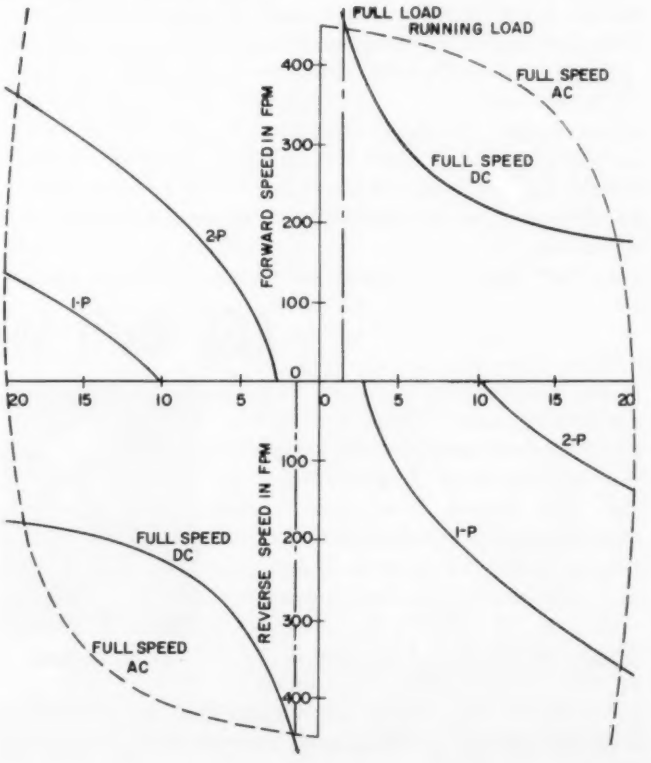


Figure 4 — Typical performance for a-c and d-c crane bridge drives.

Figure 5 — Typical speed-torque curves for a-c and d-c bridge and trolley drives.



a-c and a d-c crane and these same curves would also be typical of a trolley drive. The time rating of the trolley and bridge motor can be maintained at ½-hour just like the d-c mill motor because the a-c trolley and bridge drives can handle the acceleration and deceleration as easily as the d-c, since the high average torque on acceleration or plugging is obtained with lower peaks than with the d-c. To explain further; a given average torque with low-peaks causes less motor heating than the same average torque with high peaks.

The control for a trolley or bridge drive, whether it be a-c or d-c, generally is very simple. On a d-c drive the control consists of contactors to reverse the motor and contactors to short out the starting resistors. This is also true for some a-c drives, in that contactors are used to reverse the motor and contactors have been used to short out the starting resistors. This type of operation has generally been found satisfactory except for the wear and tear on the contactors and relays. The newer trolley and bridge controls still maintain the contactors for reversing but provide some means to steplessly accelerate and decelerate the motor. By doing this the major wear and tear has been eliminated and more desirable performance has been obtained. The better performance comes from a more nearly constant torque through acceleration and plugging and being able to obtain any value of torque under direct control of the operator. Figure 5 shows the full speed curve for an a-c drive and the reader will notice the constant torque through plugging as contrasted to the d-c plugging curves.

RECOMMENDED PRACTICES

In reviewing bids or writing specifications for a new a-c crane there are certain important features of the crane which should be checked. These are as follows:

1. Spring loaded collector shoes or trolleys should be used instead of the old counter-weighted collector shoe arrangements. This will assure good continuity of power to the hoist motor. For a high tonnage crane or a ladle crane, double collector shoes are recommended.

2. AISE standardized d-c brakes should be used on all hoists operated from their own or a common d-c power supply. General practices of locating the brake on the high speed shaft extension of the gear reducer should be followed and the torque of the brake should be at least equal to 150 per cent full load torque of the motor.

3. Any hoist with 25-ton capacity or larger should have two d-c brakes, each capable of holding 150 per cent load.

4. All production cranes should use crane and hoist type of wound rotor motors or better and each should have at least seven per cent permanent slip resistance in their rotor circuit at all times. The use of permanent slip resistance yields many benefits, such as reduced peak currents on acceleration, higher average accelerating torque, safer handling of overloaded lifts, and higher lowering speeds.

5. Static type controls should be used to increase reliability and reduce maintenance over contactor type controls.

6. Overload capacity should be checked. With d-c cranes, the AISE mill motor will on occasion handle 400 per cent load. Even though this is "not allowed" in most plants, overloaded lifts are occasionally made. The static type of a-c crane controls is designed to prevent any lift to be made above 175 to 200 per cent load. This is good practice and by limiting the peak torques the mechanical maintenance of gears, ropes, etc., is reduced. If infrequent lifts of higher capacity are contemplated, provisions can easily be made during negotiation of the crane.

7. The a-c control should provide as good or better control of the hook, trolley, or bridge than would be provided by d-c constant voltage.

8. Each hoist should be equipped with a control that provides effective "off position" braking like the off position dynamic braking on d-c cranes to keep brake shoe wear to a minimum.

SUMMARY

D-c cranes will be used for years to come because of duplication, d-c power already available and additional cranes added to existing runways. A-c cranes will take over on new installations because of the investment savings and less over-all upkeep. For a given crane, first cost of the a-c and d-c will be the same but power supply costs and the increased crane life will net a substantial saving in favor of the a-c. The use of 15 per cent more horsepower on a-c cranes will equalize production potential of the a-c crane with that of the d-c crane. By using good collectors, AISE standardized d-c brakes, two brakes on large cranes, seven per cent permanent slip resistance, static control components, good a-c crane control and off-position braking; the a-c crane will become another "work horse" for the steel industry. ▲

AISE Merit Scholarship Awarded

D. S. EVANS

An Association of Iron and Steel Engineers Merit Scholarship has been awarded to David Sidley Evans of Beaver Falls, Pa. Mr. Evans, who won the scholarship in nationwide competition, plans to attend Massachusetts Institute of Technology.

Begun in 1955, the AISE Merit Scholarship Award is part of the Association's continuing program of educational activities. This program also includes special publications, various lecture courses, and research work on selected problems in steel plant engineering.

One four-year AISE Merit Scholarship is awarded annually by the National Merit Scholarship Corp. to an outstanding high school senior who desires to study mechanical, electrical, metallurgical, chemical or civil engineering in an accredited college or university of his choice. Preference is given to children of AISE members.

David is the son of S. O. Evans, Manager—Tubing Operations, The Babcock and Wilcox Co., Beaver Falls, Pa. Mr. Evans has been a member of the AISE since 1946.

Heating Facilities for The Youngstown Sheet and Tube Co.'s New Seamless Mill

by F. C. McGOUGH,
Superintendent Fuel and Power,
The Youngstown Sheet and Tube Co.,
East Chicago, Ind.

. . . . when Youngstown Sheet and Tube set up their new seamless plant in the Chicago district, every advantage was taken of developments in technical equipment . . . . heating units were designed for capacity, quality and flexibility . . . .

PRIOR to 1957, all of Youngstown Sheet and Tube Co.'s seamless tubular products were manufactured in the Youngstown district. The decision by the company to locate its No. 3 mill at the Indiana Harbor Works indicated another major step in the development and expansion of its Chicago district operations.

Construction of these facilities was started in 1955 on filled-in ground recovered from Lake Michigan. The plant was placed in operation in the fall of 1957.

All phases of the operation were designed and engineered to utilize the most modern techniques, methods and equipment. The net result is a mill that is highly automated and capable of producing quality pipe at high tonnage rates.

Youngstown's No. 3 seamless mill produces line and merchant pipe and oil country tubular goods. The product manufactured ranges from 4½ to 9⅝-in. outside diameter tubing with a maximum finished length of 50 ft.

HEATING FACILITIES

It is evident that, in line with the thinking applied to this project, every effort would be made to provide furnaces and auxiliaries for the heating requirements of this mill that would be among the most modern of their type in the industry. The heating of the billets for piercing, the reheating of the pierced material for the plug mill, and the normalizing of the pipe product are integral and vital steps in the manufacture of seamless tube. Both the tonnage of the mill and the quality of the product are dependent upon the heating facilities adequately and properly performing their designated functions.

The heating facilities of the No. 3 mill consist of a rotary hearth heating furnace, a roll-down reheating furnace and a walking beam normalizing furnace.

THE ROTARY HEARTH FURNACE

The rotary hearth furnace heats the cold billets to a temperature of approximately 2300 F for the piercing

TABLE I

Billet diam, in.	Tube diam, in.	Lb per ft	Length, ft-in.	Billets per hr	Heating time, hr	Tons per hr
4 3/8	4 1/2	52	12-0	*190	1.02	60
4 3/4	5	61	14-10	*190	1.10	85
4 3/4	5	61	14-1	*190	1.10	81
4 3/4	5	61	11-9	*190	1.10	68
511/32	5 1/2	77	14-10	**175	1.25	100
511/32	5 1/2	77	10-6	*190	1.25	76
511/32	5 1/2	77	10-0	*190	1.25	73
6	6 & 6 5/8	96	13-10	**150	1.40	100
6	6 & 6 5/8	96	12-11	167	1.40	100
6	6 & 6 5/8	96	11-9	175	1.40	98
6 1/2	7 5/8	112	15-4	**117	1.50	100
6 1/2	7 5/8	112	12-5	**145	1.50	100
6 1/2	7 5/8	112	12-0	150	1.50	100
7 1/4	8 5/8	140	15-10	** 91	1.70	100
7 1/4	8 5/8	140	12-1	120	1.70	100
7 1/4	8 5/8	140	10-0	130	1.70	91
8 1/4	9 5/8	182	13-4	** 83	1.93	100
8 1/4	9 5/8	182	10-3	105	1.93	97
8 1/4	9 5/8	182	10-0	105	1.93	95

* Production limited by mill.
** Production limited by furnace capacity.

mill. The dimensions of this furnace are:

Furnace.....80 ft OD x 40 ft ID
Heating chamber.....20 ft wide x 3 ft 6 in. high
Hearth area.....3750 sq ft
Over all diameter.....84 ft
Door openings.....30 in. wide x 44 in. high

It is fired with either coke oven gas or No. 6 fuel oil and is designed to heat billets 4 3/8 to 8 1/4 in. OD and 4 ft-8 in. to 16 ft-6 in. long. The billets are charged in a single row radially with a minimum spacing of 2 in. on the inner diameter. Maximum billet weight is 2500 lb.

The maximum heating rate of the furnace is 100 tons per hr and the projected production and heating time for various size billets is given in Table I.

MECHANICAL EQUIPMENT AND OPERATION

As Table I indicates, it is necessary for the furnace to deliver at its maximum capacity of 100 tons per hr to meet the projected requirements of the mill. On certain sizes this necessitates the charging and drawing of billets at a rate approaching 200 pieces per hr. Therefore, in addition to a high capacity furnace, it was necessary to provide rugged and dependable mechanical equipment capable of handling billets at the fast cycle required. This machinery had to be able to withstand the severe cycle, the length of travel and the loading conditions dictated by the production requirements. Finally, both the furnace and its mechanical auxiliaries had to conform to the general pattern projected for the mill that all of its operations be automatic to the greatest extent practical.

Essentially automatic operation had been successfully attained in at least one mill of the reducing type operating in approximately the same range of cycles. However, in this case, the charging of relatively short material permitted the end clamping of the heated billet. In this mill the high length-to-diameter ratio of the billets precluded end clamping of the heated material and therefore, dictated side clamping of the billets for unloading the furnace. To accomplish fully automatic operation, it was necessary for the billet to be positively indexed in the charge end and remain in place as it traveled through the furnace so that it would be within the tolerance of the discharger clamping arrangement. This tolerance is more critical in side clamping than it is in the case of end clamping.

It appeared that charging would present no major problem since end clamping the billet and charging it on a properly maintained bottom should place the piece reasonably close to the index at the discharge door. Therefore, the principal concern was the automatic operation of the side clamping unloader.

The mechanical operation of the furnace and the charging and discharging equipment is essentially as follows:

The hearth rotates on a series of beveled cast steel wheels which are anchored on the foundation. The wheels turn on anti-friction roller bearings and engage circular tracks mounted on the underside of the hearth table. The beveled gears serve to maintain the hearth in true relationship with the theoretical center. As a safety precaution restraining wheels are mounted in the inside well of the furnace and designed to rotate on a vertical axis. The wheels are not engaged unless the hearth moves off its true path.

The steel supporting the track of the furnace's rotating mechanism was made considerably heavier than had been general practice. This was done to stabilize the entire system against the severe inertia encountered in starting and stopping.

The hearth is driven by a dual drive. Each drive has its own speed reducer, reduction gears and drive pinion. The two pinions, 180 degrees apart, engage the continuous gear segments mounted on the outside face of the hearth table at the outer periphery. Both drives are powered by one constant speed motor through a standard automotive type differential.

The hearth rotates clockwise in a step-by-step movement at time intervals controlled by an automatic timing device. The amount of hearth movement is adjusted by means of a selector switch which divides the hearth into the proper number of stations to produce the required number of heated billets of a certain size per hour.

The billets are manually loaded on the inlet table which in turn positions them under the furnace charger. Following the advancement of the hearth one station, the charger and discharger simultaneously enter the furnace at their respective automatically operated doors. The charger boom lowers and unclamps, the discharger boom lowers and clamps. Both booms then raise and both machines retract. The charger lowers and clamps another cold billet at the same time the discharger releases the heated billet which is delivered to the mill by the hot stock conveyer. In the interim, the time cycle has been completed and the hearth advances one station. This sequence is repeated unless manually interrupted by the operator because of a mill delay.

Both the charger and discharger are identical in construction except for their clamping mechanisms and their movements which are in the reverse order. All operations are interlocked to insure that the required movements take place in their proper sequence and that the moving components are in their correct positions.

Provision is made so that the automatic step-by-step operation of the hearth may be by-passed and it can be kept in continuous motion during heating up and cooling periods. The normal clockwise rotation of the hearth may also be reversed in case of an emergency.

COMBUSTION SYSTEM

From the standpoint of fuel engineering, the fact that it was required to heat billets varying in length from 4 ft-8 in. to 16 ft-6 in. was a matter of concern. An analysis of the sizes projected for the mill indicated that, on an average, ⅔ of the heating load would be concentrated on the outer half of the hearth. On the shortest billets, the loading would be entirely on the outer half while on the longest billets it would be practically balanced. The condition was further complicated by projected production rates of certain sizes of short billets which required heating at rates approaching 100 tons per hr.

Therefore, a problem was presented where high heat release was required on the outer half of the hearth when heating most of the sizes while balanced fuel input was necessary when heating longer billets. Further it was recognized that long flame burners of the type generally applied to rotary furnaces had characteristics which usually resulted in overheating the inner half of the hearth.

The first step taken to insure quality heating at the projected high tonnage rates was the consideration of the burner design to be applied. Instead of luminous flame gas burners, the furnace was equipped with the clear flame nozzle mix type. The characteristics of these burners were such that the development of the flame and the completion of combustion could be attained closer to the burner parts than was possible with luminous flame burners.

Secondly, on the basis of releasing heat in accordance with the actual steel loading, approximately ⅔ of the total fuel was applied to the outer wall and the remaining ⅓ to the inner wall of the furnace. Also, the burner capacity was over-sized to the extent that the fuel input of the outer burners alone could almost satisfy the heat requirements for maximum tonnages. For the purpose of control and fuel application, the furnace was divided into six zones as shown in Table II.

The total fuel input exceeding a quarter of a billion Btu's per hr is high for a heating furnace of any type, particularly for an 80 ft OD rotary furnace. However, this amount was deemed necessary when considering the flexibility of firing required, the large hearth area of 3750 sq ft and the high projected tonnage rates.

A third step taken to insure quality heating of the various length billets was dividing each of the main heating zones, No. 2, 3 and 4 into two sub-zones. In each case, the burners located on the outer wall make up one sub-zone while the burners on the inside circumference make up the other. The temperature control on each of these zones is especially equipped so that any desired percentage of the total fuel being fired may be split between its two sub-zones. The temperature of the zone is then automatically controlled by varying the total fuel input at this predetermined proportion. In this manner it is possible to regulate the firing of each of these zones across the width of the hearth to insure uniform heating of the different length billets.

The combustion flue gases move counterflow to the hearth rotation and steel travel, exhausting through an opening in the arch just ahead of, and adjacent to the charging door. This opening is segregated on either side by two 180-degree air-cooled drop noses. From here the flue gases travel through an uptake and into an overhead breeching connected to the stack.

Two similar drop noses modify the contour of the arch between zones No. 3 and No. 4, and between zones No. 4 and No. 5. A suspended refractory baffle separates the charging and discharging doors of the furnace.

Combustion air for the firing of the fuel is supplied by four 8-oz blowers. The total capacity of these blowers is 20 per cent greater than the requirements for the maximum fuel input.

TABLE II

Zone	Degrees	Outer wall		Inner wall		Total	
		No. burners	Million Btu per hr	No. burners	Million Btu per hr	No. burners	Million Btu per hr
No. 1 (charge)	87	Unfired	0	Unfired	0	Unfired	0
No. 2	60	12	54.0	6	27.0	18	81.0
No. 3	60	10	45.0	5	22.5	15	67.5
No. 4	65	10	45.0	5	22.5	15	67.5
No. 5	50	8	18.0	4	9.0	12	27.0
No. 6	20	3	13.5	2	9.0	5	22.5
Totals		43	175.5	22	90.0	65	265.5

REFRACTORIES

The vertical side walls of the furnace consist of 9-in. of 2800-F insulating firebrick, backed up with 4½ in. of 2000-F insulating firebrick and 1-in. of block insulation. The roof is of the suspended arch type and is composed of 9-in. superrefractory shapes covered with 2½ in. of insulation. The furnace hearth consists of 4½ in. of 70 per cent high alumina superrefractory brick, 4 in. of baffle mix, 4½ in. of insulating brick, all laid on 4 in. of insulating concrete.

The inside vertical wall is mechanically anchored to the steel shell of the furnace by means of high nickel alloy studs. Since there are no flues in the vertical walls, the entire furnace construction is such that radiation losses are held to a minimum.

INSTRUMENTS AND CONTROLS

The furnace is equipped for the fully automatic control of fuel-air ratios, furnace pressure and temperatures. The combustion control is hydraulically operated and the temperature control is of the pneumatic type. All of the pertinent flow, pressure and temperature conditions are metered and recorded.

There is a total of eight fuel-air ratio control systems, one for each of the sub-zones of the three main heating zones (No. 2, 3 and 4), one for the soaking zone (No. 5) and one for the discharge zone (No. 6). The impulse for

TABLE III

Outside diam, in.	Wall, in.	Pieces per hr	Piece weight, lb	Tons per hr
5	0.452	188	836	78
5⅞	0.460	168	1020	86
6⅞	0.564	155	1440	112
7½	0.586	135	1630	112
8½	0.571	117	1820	107
9½	0.591	94	2200	103

the furnace pressure regulator is taken from the sidewall of the furnace's discharge chamber. The pressure is controlled by operating a butterfly damper installed in the overhead connecting flue leading to the stack.

All of the five burner-equipped zones of the furnace (No. 2, 3, 4, 5 and 6) are temperature controlled by air-operated recorder-controllers of the electronic type. Each of these instruments are equipped with a switch so that the point of control may be selected from either of two radiation type measuring elements. These are located in the arch of each zone, one adjacent to the outer wall and one adjacent to the inner wall. This arrangement allows the operator to determine temperature differentials across the hearth and, as previously described, proportion the fuel to the sub-zones as required to uniformly heat the various length billets. A control station is located at the unloader so that the temperature of the heating zones may be remotely reduced by the operator to a predetermined safe minimum in the event of a mill delay.

A circular hearth loading indicator indexes the various heats on the hearth. This indicator shows all furnace doors and zones to scale, and is driven in positive index with the hearth by means of selsyn units.

THE ROLL-DOWN FURNACE

The reheat furnace is a roll-down type and heats the pierced tubes from approximately 2000 to 2200 F for delivery to the plug mill.

The dimensions of this furnace are:

Furnace (inside) 17 ft long x 43 ft wide x [4 ft-1 in. high (charge) 3 ft-2 in. high (discharge)].

Furnace (over-all) 21 ft long x 47 ft wide x 11 ft 9 in. high.

It is fired with coke oven gas and is designed to reheat 5 to 9½-in. OD tubing in 38 ft lengths.

The projected tonnage of this furnace reheating 38 ft lengths of various size tubes from 2000 to 2200 F is given in Table III.

OPERATION

The tubes are individually charged into the furnace by a conveyor and travel the width of the furnace on water-cooled rollers until they engage a stop inside the furnace. This in turn energizes a kick-off mechanism which pushes the tubes off the rollers onto the water-cooled skid rails located in the furnace bottom. The tubes then roll down the sloping portion of the hearth to a 3 ft horizontal section. Manually-operated bumper stops prevent the pipe from rolling down to the water-cooled discharge rolls until required. The individual tubes are then discharged from the rolls onto a conveyor to the plug mill as required.

COMBUSTION SYSTEM

The furnace is fired by 18 burners located across the width of the furnace and close to the arch at the charging end. The products of combustion travel along the roof toward the discharge end and return downward in a horseshoe pattern to the charging end. The flue gases exhaust through downtake flues located in the bottom of the roll recesses at the firing end and from there through the main flue to the stack. The total fuel input of the 18 burners is 54,000,000 Btu per hr.

REFRACTORIES

The furnace walls are constructed of 13½ in. of first quality firebrick backed up with 4½ in. of 2000 F insulating brick and 1 in. of block insulation. The furnace hearth is constructed of 4½ in. of 70 per cent alumina brick, 9½ in. of first quality firebrick and 5 in. of 2000 F insulating brick all laid on 4½ in. of insulating concrete. The furnace roof is of suspended arch construction and consists of 9 in. of first quality firebrick covered by 2 in. of block insulation.

INSTRUMENTS AND CONTROLS

For the purpose of control, the bank of 18 burners across the width of the furnace is divided into three zones. Each of the zones are fully equipped with metering, hydraulically-operated fuel-air ratio control and pneumatic temperature control. The furnace pressure is automatically controlled by a hydraulically-operated damper in the flue.

THE NORMALIZING FURNACE

For the final heating operation of the mill, a three-zone furnace of the walking beam type was installed for either normalizing or tempering the hot finished seamless tubes. The dimensions of this furnace are:

Furnace (inside) 68 ft-8 in. long x 54 ft wide x [5 ft-0 in. high (heating zone). 4 ft-9 in. high soaking zone)].

It is fired with coke oven gas and is designed to normalize 4½ to 9⅝-in. OD seamless tubes in maximum lengths of 50 ft for range No. 3 tubing and minimum lengths of 16 ft for range No. 1 tubing.

The rated production for this furnace charging tubes at 500 F and normalizing them at 1700 F is given in Table IV for various sizes.

FURNACE OPERATION

Seamless tubes enter the furnace through a charging door in the sidewall and move across the width of the

TABLE IV

Outside diam, in.	Wall, in.	Lb per ft	Pieces per hr	Total time in furnace, min*
4½	0.250	11.35	155	27.0
5½	0.275	15.35	155	27.0
7	0.362	25.50	155	27.0
8⅝	0.352	31.10	117	36.0
9⅝	0.352	34.86	94	44.5

* The above heating times include 15-min soak. The maximum tonnage is 90 tons per hr of 7-in. tubing.

furnace on motor-driven rollers. After they are properly positioned, the leading end of the tubes engage a bumper which actuates a side pushing mechanism which moves the tubes from the cantilevered rollers onto the walking beam mechanism. The tubes then move progressively through a heating zone and two soaking zones to the discharge position. A stop-and-release mechanism at this location permits one tube at a time to move onto the furnace discharge rollers and out of the furnace.

COMBUSTION SYSTEM

The length of the furnace is divided into three zones by drop noses as follows:

Zone No. 1 (heating).....24 ft-6 in. long
Zone No. 2 (soaking).....23 ft-0 in. long
Zone No. 3 (soaking).....21 ft-2 in. long

Each zone is fired across the width of the hearth with burners of the tempered flame type. The burners of No. 1 zone are located in the charging wall above the inlet rollers and fire toward the discharge end of the furnace. The products of combustion pass over the tubes and then horse-shoe back over and under the tubes traveling down between the inlet rollers through the furnace bottom to an underground flue leading to the stack.

The burners of No. 2 zone are located in the vertical wall formed by the 90-degree nose arch segregating zones 2 and 3 and fire toward the charging end of the furnace. The burners of the second soaking zone, zone No. 3, are located in the discharge wall above the outlet rollers and fire in the same direction as No. 2 zone.

The total fuel input of the furnace is 130,200,000 Btu per hr divided as follows:

Zone		*No. burners*	*Btu per hr.*
1	(heating)	21	105,000,000
2	(soaking)	21	12,600,000
3	(soaking)	21	12,600,000
Totals		63	130,200,000

REFRACTORIES

All the sidewalls of the furnace are constructed of 9 in. of 2300-F insulating brick with the exception of the burner walls which consist of 13½ in. of 2300-F insulating brick. All these walls are backed by 1 in. of block insulation. The roof of the furnace is the suspended type consisting of 9 in. of 2300-F insulating firebrick backed with insulating cement. The nose arch construction is also of the suspended design and consists of 10 in. of first quality firebrick. The hearth is constructed of 4½ in. of first quality firebrick, 5 in. of 2300-F insulating brick and 3 in. of insulating concrete.

INSTRUMENTS AND CONTROLS

Each of the three zones is fully temperature controlled by air-operated recorder controllers. In applying the tempered flame burners, a quantity of combustion air in an amount capable of satisfying the maximum fuel input remains on the furnace at all times. Therefore, no fuel-air ratio control was installed on this furnace. The furnace pressure is automatically controlled by a hydraulic regulator operating a butterfly damper in the flue. All pertinent flows and pressures are metered and recorded.

Discussion

PRESENTED BY

M. S. GETTIG, Assistant General Superintendent—Steel Plant, The Youngstown Sheet and Tube Co., East Chicago, Ind.

D. R. BAKER, Combustion Engineer, Steel & Tube Div., Timken Roller Bearing Co., Canton, Ohio

F. C. McGOUGH, Superintendent Fuel and Power, The Youngstown Sheet and Tube Co., East Chicago, Ind.

JAMES E. HOVIS, District Manager, Bloom Engineering Co., Cleveland, Ohio

JAMES MACGREGOR, Sales Engineer, Pipe & Tube Mill Div., Aetna-Standard Div., Blaw-Knox Co., Pittsburgh, Pa.

M. S. Gettig: First, it may be of interest to those present that it was necessary for us to build twenty acres of land on the shore of Lake Michigan on which to erect the new seamless mill. The buildings cover almost an even ten acres and the entire building as well as heavy machinery, including the furnaces, are set on approximately 450,000 ft of 10-in. piling.

The rotary furnace is to the best of our knowledge the largest of its kind in the world and does a very excellent job. I have never seen a furnace perform as nicely as this one does.

We have had some difficulties with this furnace as in all new equipment. The hearth of this furnace is composed of a 2-in. layer of roll scale on top of the brick hearth. This roll scale forms a bed on which the billets are laid by the charging machine. Because the operation of this furnace is fully automatic, the hearth must index a fixed distance after every round is charged and must be in an exact position when the hearth has rotated the round to the discharge position. Obviously any change in the position of the round after it is placed on the hearth would have an effect on its relation to the discharge mechanism. The main difficulty in this respect arises from cambered rounds which permit them to roll as they are laid on the hearth. Another difficulty arises from disturbance of the roll scale bed. Small rounds are charged more closely together than large rounds with the result that when changing from one size of round to another, the different sizes do not lay in the same "groove" on the bed and may roll slightly to one side or the other.

These difficulties, however, have not caused any real trouble because the discharging machine is equipped with a jaw clamping mechanism which allows for displacement of the round laterally to the extent of about 4 in. in either direction. The jaw clamping used on the discharge is not the same as the end clamping as used on the charging machine. This type of clamping was used because we felt a long, small diameter round would not have sufficient column strength when heated to rolling temperature to withstand end clamping.

Much to our chagrin, however, we have found that

with the side clamping, near the center of the length, ends of the small diameter, long length rounds tend to droop and make withdrawing from the furnace difficult. We have overcome this by clamping closer to the front end of the round and permitting the back end to drag as it comes from the furnace.

We have not run the full range of sizes on this mill and we may find more difficulties when we try larger rounds such as 8¼ in. OD x 14 or 15-ft long. We have no way of knowing what further difficulties may develop when we try these larger items but whatever they may be we are confident we will not be in too much trouble in overcoming them.

We would like to reiterate here that this furnace operation is fully automatic. Heating controls have been described and the charge and discharge mechanisms are operated by both mechanical and hydraulic means. The heater has nothing to do but watch the furnace operate and regulate the heating controls when necessary, the operating speed in cycles per minute (this is adjusted on the operating pulpit just by turning a knob on the automatic timer) and shut the furnace off when a mill delay occurs.

The operation of this furnace is phenomenal and the cycle can be set very rapidly. We have had the complete cycle from piece to piece down to 17 sec.

The mill started to operate September 30, 1957, and because of business and other conditions has operated only a total of nine months up to the present time.

In regard to the reheat furnace, we mentioned water-cooled skids. The water-cooled skids were put in in such a way that we had three ft of horizontal refractory hearth before the shells went on to the discharge roller.

We had the same trouble that every other tube manufacturer has had with the refractory hearth furnaces picking up the scale and following through the rolls to cause rolled-in pits.

We had to tear out the original water-cooled skids and refractory hearth, and put in full length water-cooled skids. In doing so we have practically overcome any tendency to furnace pitting.

On the normalizing furnace, we have a very unique type of walking beam in that we have an elliptical motion on the beam which transfers the pipe from one wave to the next one in such a way that the pipe rolls and at no time does it drag on the stationary skids as compared to the reciprocating skid.

D. R. Baker: There are considerable differences in comparison of this furnace to the original rotary furnace built at Timken Roller Bearing Co. for heating billets for tube mills and probably most of the changes are improvements.

However, there are a few points in question that were not covered in the paper.

1. We would like your experience or expected results, if you have any figures or care to give them, on fuel per ton.

2. Mr. McGough commented slightly on the maintenance of the hearth but we were wondering whether you get grooves or a notching effect in the hard brick hearth from dropping billets during charging, and whether or not the timing of the charging and discharging machine is effected by the billets rolling into the grooves.

3. Is it difficult to make repairs with a roof height of only 3 ft 6 in. or do you have a removable portion of the roof?

4. Another point we were wondering about was the rate of heating. We notice that you attempted to achieve a rate slightly less than 15-min per in. diameter and on the original furnace it was calculated on a 20-min per in. schedule. Do you attribute the faster rate of heating to the lower roof, faster mixing burners or do you carry a higher heat head than your final temperatures?

5. Do your sub-zones require frequent changing?

6. Were recuperators ever considered in the design of this furnace?

F. C. McGough: In answer to Mr. Baker's first question, we anticipate a fuel per ton figure of approximately 2,000,000 btu when the operation approaches its designed tonnages. As to further information on the hearth maintenance, I will refer this question to Mr. Gettig.

Replying to the third question, to date no major repairs have been required on this furnace. We do not, however, have a removable roof arrangement.

As to the high rate of heating, it is our opinion this is possible due to furnace design and the high capacity burners.

In answer to Mr. Baker's fifth question, temperature of the zones are changed as required for mill operation and varying billet weights. I will refer the last question, regarding the consideration given to recuperators, to Mr. Gettig.

M. S. Gettig: In regard to the maintenance of the hearth, I believe that Mr. Baker misunderstood what I had to say. Our hearth is brick. The brick is the base, but on top of that we built a 2-in. roll scale layer to bed the billets, and we do not drop the billets on the hearth. They are laid on the hearth by the charging machine, which is by end clamping.

We end-clamp on charging because there is enough column strength. We do not drop the billets on the hearth, and their bedding is in the scale which prevents them from moving.

In regard to the maintenance of the hearth, once a week we go in with a long rod and turn the doughnut of the furnace, and smooth out the scale. That is a very simple operation, very easily done, and we have no difficulty with it.

I have been on the planning of this mill all of the way from the start, and although some of the fuel engineering work was done at Youngstown, Ohio, to the best of our knowledge we never considered putting recuperators on this furnace.

We have been operating under relatively high speeds on the mill to date, and our fuel rate is going to be very excellent. I would not attempt to quote you any figures. I know we expect to heat a lot cheaper than we did the old roll-down furnace, and we do a much better job of heating.

On the question of 20 min to the inch, you will find that an old rule of the thumb which has been used for twenty-five years in the seamless industry for heating steel. I believe now that we do not need 20 min to the in. to heat steel or anywhere close to it. You can probably get down to 15 or perhaps less minutes to the inch on seamless rounds and it will be all right.

James E. Hovis: A design figure of 15 min per in. of

thickness has been mentioned here. The furnace at the maximum rated capacity is based on a heating cycle of 14 min per in. This figure was arrived at by actually calculating the heating curve for the design size billet.

In other words, this furnace was not designed by rule of thumb. To do this, it is necessary to select a furnace temperature curve—a heat pattern in the furnace required to accomplish the job. From this selection, which is based to a large extent on the judgment, the heating curve of the billet can be calculated. In this case, it came out to 14 min per in.

The fuel input has to be applied in accordance with that heating curve. In other words, if we are putting 100 Btu per lb into steel in zone No. 2, according to that curve, we have to have the fuel applied on zone No. 2 commensurate with that requirement. It is as simple as that.

The author has mentioned the overburnering of the furnace with 268,000,000 Btu per hr. We should run about 1,800,000 to 2,000,000 on a straight run basis solely dictated by the necessity of heating short billets on the one hand, and long billets covering the entire hearth width on the other hand. That, of course, also comes from a basic analysis of the heating requirement.

The control which entailed three additional zones of fuel-air-ratio, considerable extra piping, and some auxiliary temperature control equipment meant a lot of money spent. Was it necessary and do you feel that expenditure was justified?

F. C. McGough: It is our opinion that the performance of the furnace to date, limited as it has been, justifies the expenditures for the control system.

M. S. Gettig: The normalizing furnace with the exception of one or two items which has been now worked out, is the best furnace I have ever seen for tabular work. The quality of heating we get out of it is second to none anywhere in the country.

In regard to the rotary furnace, I think we have controls on that furnace that are second to none in the country, and you can handle it any way.

There are no two furnaces in the country that will come up to them.

Member: I think you said that 9 ft was the longest billet that you heated.

M. S. Gettig: Twelve to thirteen at present with 16 ft 6 in. maximum.

James MacGregor: When you were discussing the normalizing furnace, you said that the furnace at Indiana Harbor was one of the best designed and operating units you had ever seen, and that it was doing an excellent job of handling the product. You also mentioned that the product is rotated as it is transferred through the furnace.

Would you say that the success of your normalizing operation was primarily due to the effect of rotating the pipe as it is transferred through the furnace on the walking beam, and that the rotation of the product permits a uniform heat absorption for the entire length of pipe?

M. S. Gettig: One phase of the success of the furnace is due to the fact that it rotates all of the time. I do not think that entirely is the answer. The burner zoning, and fuel combustion in gas furnaces are also very important, but I would not detract from the importance of rotating the work in these furnaces.

James MacGregor: In other words, temperature control is very important. You must have a uniform temperature throughout the furnace, if you desire to effectively normalize with uniform heating of the product. This is more permissible with the design and construction of the furnace you have explained since it apparently permits sealing of the hearth to effect the controlled uniform temperature desired. You say you are cross-firing the furnace which gives you the most effective results. However, I do not think it would be possible to get your end results, if you were not effectively rotating the product as it is transferred through the furnace, which permits the hot gases to flow over the entire surface of the pipe as it progresses through the furnace on the walking beam.

M. S. Gettig: It was necessary to get heat to the top side of the billet from the roof of the furnace and also by contact of combustion gas. At the same time it was necessary to get heat down underneath to the hearth. If you depended on the fact that it did not rotate and depended entirely upon the radiation of the hearth back to the bottom side of the tube certainly, you would not get uniform heating, and that is the reason I say the rotation is the biggest asset.

James McGregor: At what temperature is the product going into this furnace? How do you control the temperature drop of the product coming from the mill, which is approximately 1750 or 1800 F to something below the upper critical temperatures prior to entry into the normalizing furnace, and still keep up with mill production?

M. S. Gettig: We are well under the critical points of any of the steels which we are normalizing.

James MacGregor: With that type of operation where you want an in-line operation, and this is based on an in-run of about 800 F, is there the possibility of shortening the hearth time?

M. S. Gettig: I do not think there is any question you would shorten the hearth length if you could have everything going into the furnace at 800 F or so. Principally it is a heat saver with us, but then it carries on for the next operation, and you already have it ready, and you have your temperature simultaneously.

James MacGregor: You said your furnace was designed also to carry all of your mill tonnage that would be normally run. Does it keep up with the total mill production?

M. S. Gettig: The furnace was designed for 155 pieces per hr, and the mill has a theoretical maximum of 180 of range 3 pipe. If we get over 155 pieces an hour on 5½-in. range 3 pipe, we are going to have to lay quite a bit of it down.

We are figuring on higher speeds than 155 an hour, the maximum speed of the furnace.

James MacGregor: I notice that you use double spacing on the walking beam for the larger product sizes. Is this a normal operation to double space, and does it effectively keep up with mill production?

M. S. Gettig: That is right.

James MacGregor: What is the maximum size product that can be single spaced on the walking beam?

M. S. Gettig: Off hand I think it is 7 in.

James MacGregor: Up to 7 in. on single space, is from 7 in. up double?

M. S. Gettig: Yes. ▲

Figure 1 — The hook block is in its normal "main" capacity position. The upper block is nested on top of the lower block. These two blocks can be locked together by the action of the "T" block locks. This locking together of the upper and lower blocks is done manually by the floor rigger.

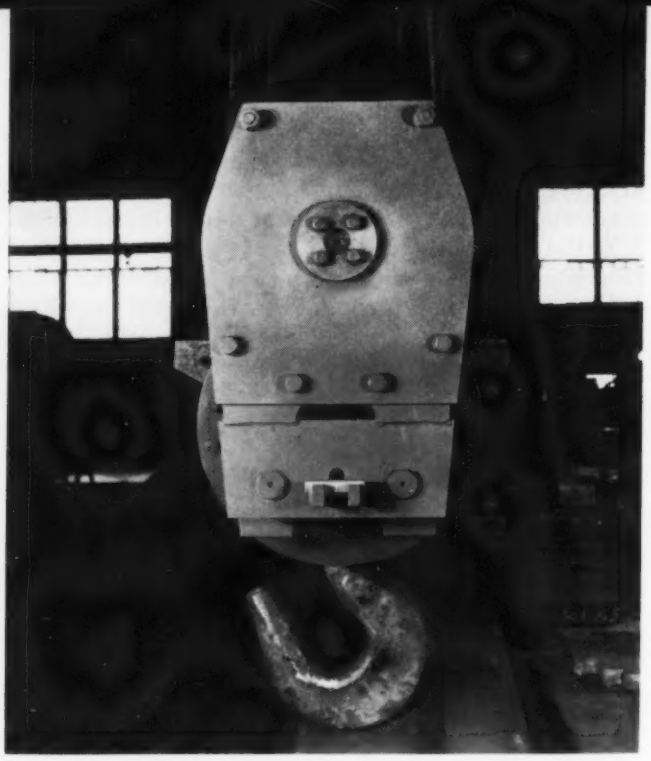


Figure 2 — Full side view shows how the two triangular extensions extend out to either side of the lower block, beyond the width of the upper block. This is the key to the block action.

Dual Capacity Hoist for EOT Cranes

by DONALD SCHAPER,
The Morgan Engineering Co.,
Alliance, Ohio

. . . . a device gives a single hoist crane the advantages of the dual hoist by an ingenious mechanical mechanism . . . . economy and space savings plus closer hook approach are thus available . . . .

ONE of the most frequent questions encountered in the early design stages of overhead cranes, is the question of hoist capacity and speed. The user of overhead cranes, as well as the builder of this equipment, must decide this matter not only on the basis of the maximum lifted load involved but, also, the speed of movement of all loads from maximum on down to minimum.

The most widely accepted solution is to separate the

Figure 3 — When the block is used for its "main" capacity, the upper limit stop functions in the same way as on any other mill crane. The power-type limit switch cable extends through the trolley deck, in order to support the end of the limit stop arms. Since the extensions on the lower block are about to strike the limit arms and since the blocks are locked together, any further attempt to hoist the load will, in turn, trip the limit switch.

duties: that is, to equip the crane with two separate hoist units, the main hoist to lift the maximum load at slow speeds and an auxiliary hoist to lift lighter loads at fast speeds. This, of course, requires two separate hoist drives consisting of motors, brakes, control, gear drives, drums, ropes, and hook blocks.

Since in many cases the power involved between the main hoist assembly and the auxiliary hoist assembly is very much the same, the question brought to mind is this, "Cannot one hoist drive unit be designed which will serve either function of a slow main hoist or a fast auxiliary hoist?"

Remembering that frequently the consumed power is nearly equal, and assuming it here also applies, the problem now results in designing one hoist unit that can at will change its mechanical advantage with the resulting change in speed.

This question has been raised many times. The problem has been approached from the motor through electrical means. Perhaps this change of mechanical advantage has been accomplished in the gear reducer in the past. However, after studying this problem, the hoist mechanism repeatedly appeared to be the most obvious area in which to effect a positive change in mechanical advantage. This area is the rope reeving to the hook block. Not only has the re-reeving principle allowed a very simple solution to exchanging speed for capacity at the crane hook, but it has actually allowed this exchange without affecting the speed or torque of the hoist drum, gearbox, motor, or to project still further, with no change in control. In its simplest

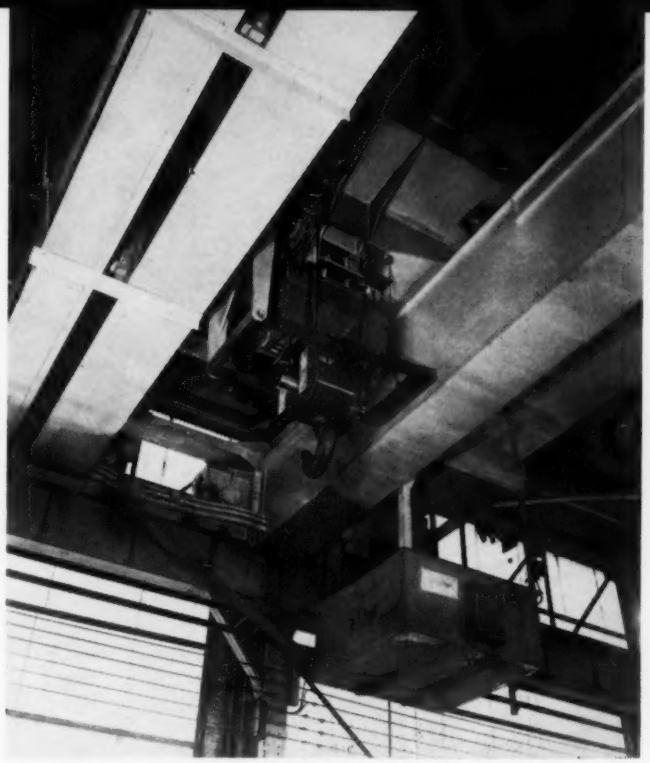
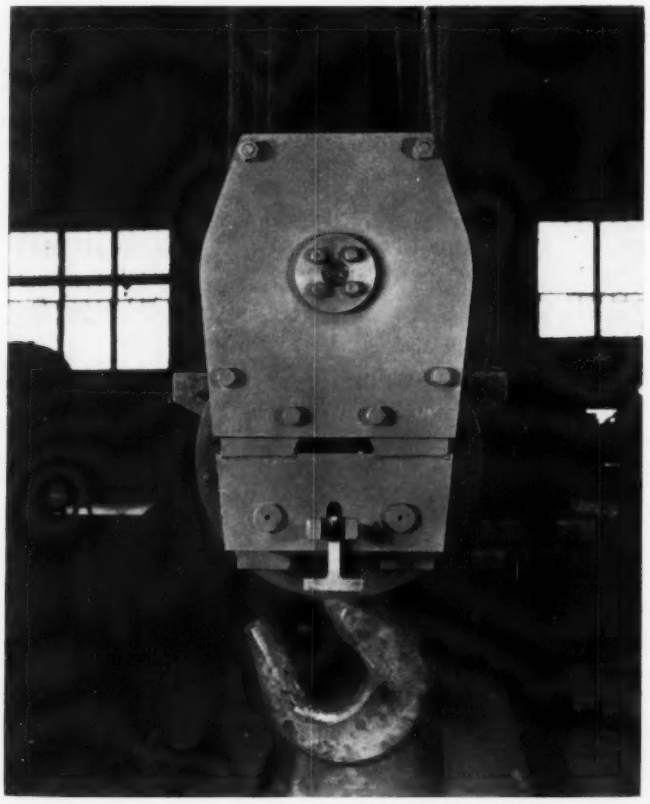


Figure 5 — The block is raised up against the limit stop arms to separate the auxiliary block. As the lower block strikes the weighted stop arms, its upward movement is halted by weight of limit stop frame and further hoisting movement lifts the upper block up into the four upper block locks, seen projecting down from the cushioned stop plate. As soon as the upper block locks against the stop plate, the lower block now has no alternative but to raise the stop arms, thus tripping the power limit stop above the trolley deck. Now the entire locking action has taken place with the controller on the hoist position, with the crane operator exercising a "hands off" attitude. The action is halted with the upper block locked on the trolley frame, by the automatic action of the limit switch through the stop arms.

Figure 4 — In order to change the hoist from "main" capacity operation to "auxiliary" operation, the pair of blocks is lowered to the floor level, and the block locks are manually unlocked by the floor rigger. The blocks are here unlocked, and the first step in resetting for "auxiliary" capacity operation is now completed.



definition, the dual capacity hoist is: "An Automatic Re-Reeving Device."

The principle on paper is extremely simple and direct. It was that very simplicity that perhaps caused more concern than the future design problems which were to come.

For this reason, a wooden model of the dual capacity hoist was designed, built and displayed at the 1958 AISE Annual Convention in Cleveland, Ohio. It was the intention at that time to receive comments on the model, not only from an engineering standpoint, but from an application standpoint. A wooden, working model was reviewed by customers, as well as competitors, with an eye to its place in the steel mill. This experience developed that the dual capacity hoist lends itself to powerhouse cranes, warehouse cranes, roll changing cranes; in general, those cranes requiring a single hook whose principal duty is auxiliary hoist operation, with perhaps, only occasional need for the main hoist operation.

The most obvious reason for the dual capacity hoist is the cost savings in eliminating one of the hoist units on the trolley deck, with its accompanying elimination of one hoist control. Another advantage is the closer end approach that is available due to elimination of the second hoist unit. While the wooden model was a help,

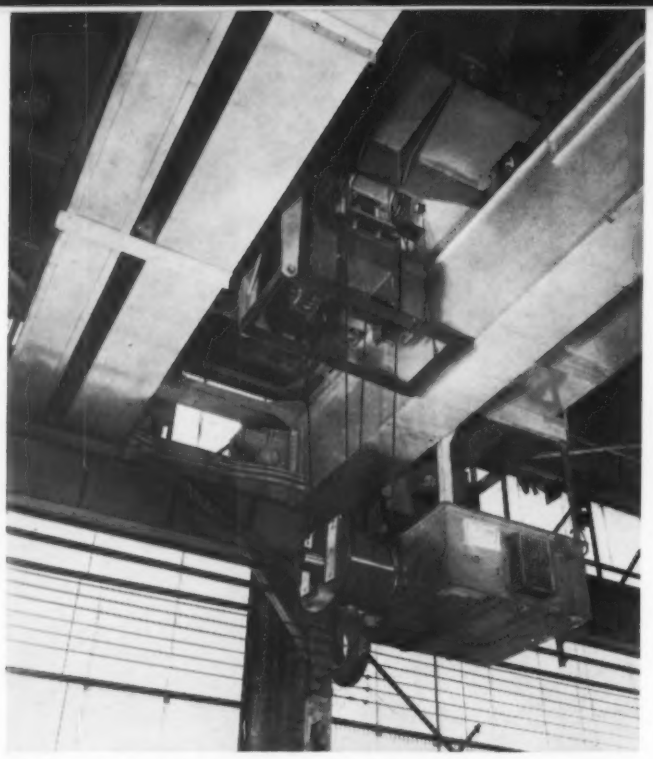


Figure 6 — The transition from main hoist to auxiliary hoist is now complete. The lower block is now lowered for its job. The rope reeving, now reduced to 4 parts, results in a speed increase of three to one, over that of the main hoist operation, with, of course, an accompanying reduction in capacity.

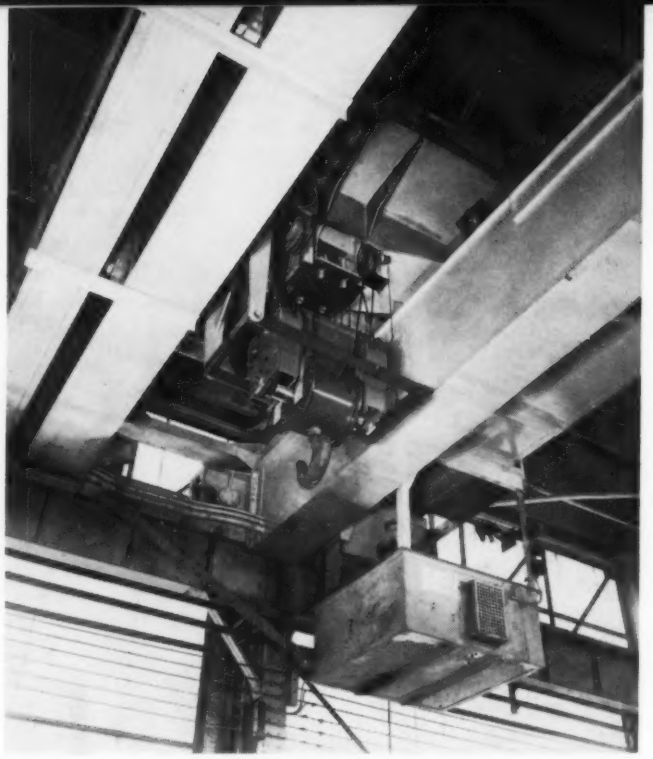


Figure 7 — If it is desired to again use "main" capacity block, the steps are reversed. The lower block is raised up until the limit switch is tripped. The crane operator pushes the upper lock release solenoids, while at the same time moving his controller lever to "lower," and the unlocked upper and lower blocks move down together. The rigger will then insert the "T"-block locks at floor level.

only a full size working model of the dual hoist could furnish true test data.

Several months ago, we selected a 35-ton crane, with a 15-ton auxiliary, for modification with our dual capacity hoist. The 35-ton crane main hoist hook block was replaced by a dual hoist block and, in addition, we modified the underside of the trolley frame to receive the solenoid operated "upper block locks" and the new "limit stop arm." We made absolutely no change on the existing main hoist control, motor, gearbox, drum, or electrical limit switch. The existing crane mechanism, above the trolley deck, is completely unaware of the re-reeving below deck and its affect on hook capacity and speed.

Figures 1 through 7 show the first full size, actual working model of the dual capacity hoist.

While the figures show the relative positions of the split block during main or auxiliary operation, questions may occur that we will try to anticipate in this paper.

The upper and lower blocks are locked together manually at the floor level by the floor rigger. For the present, we have made no attempt to do this automatically or by remote control.

The four upper block locks, in the trolley frame, are the first of a series of designs and by no means final. It is interesting to note that these locks do not hold up the upper block but only the intentional overbalance between lower and upper block. This overbalance amounts to only a few hundred pounds.

Again the upper block locks are released by a push-button in the crane cab and are electrically interlocked so as to require that the lower block be up against the limit stop arms before the upper block can be released. This is to prevent the unintentional dropping of the upper block while on auxiliary hoist operation.

The limit stop arms are weighted in such a way as to stop the lower block's upward movement, thus forcing the upper block up into the upper block locks. The power-type limit stop will not trip until this step is complete.

The dual hoist uses only one upper limit stop, the same way as any standard crane does. In addition to limiting the hook blocks upward travel during normal main or auxiliary hoist operation, it also stops the locking sequence of the upper block into the upper block locks without the aid of the crane operator.

The maximum capacity of the dual hoist has not, as yet, been determined. The principle seems sound for any capacity. The ratio between main and auxiliary capacity for our first model is three to one; however, two to one, or four to one, appear to be equally feasible.

In some capacities, the size of the single hook, which doubles as a main or auxiliary hook, may be objectionable. Several schemes are available; the most obvious being to design the single hook to the auxiliary capacity and rely on side clevises for main hoist operation. These clevises would be mounted on the upper block and would, incidentally, eliminate the need for the lower block locks.

The future of the dual hoist is yet to come, and we are first to declare that its application is an individual question to be answered only after examination of the duty involved. The usual field problems, which are bound to occur in any development program, have been solved without causing any serious doubt as to the ultimate practicability of the dual capacity hoist. As the development program continues, we feel certain that the dual capacity hoist will assume its proper place in the steel mill industry. ▲

PRODUCTION PLANNING For An Integrated Steel Plant

Programming to give good customer service while insuring profitable operations is one of the production planning department's major responsibilities.

by A. E. LAWRENCE,
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THIS paper consists of a broad and general description of the background, the purpose, the function, the organization and the activity of production planning at division and works levels. Figure 1 is a rather simple chart of the over-all steelmaking process and production flow in an integrated steel plant. In this process, perfect co-ordination of material flow, identification and sequence through all of the individual production processes and inventory points is essential to optimum finishing mill scheduling, good shipping practice and the maintaining of customer commitments. Co-ordination between the finishing mill schedules and the shipping schedules must be maintained through all of the preceding units so that constant changes are not required back through all phases of production, unusable or slow-moving inventories are not accumulated between processes and customer delivery commitments are maintained. Let us first review the key producing facilities in an integrated plant.

Figure 2 is a view of the coking process. The coal after about 18 hr in the ovens, at a temperature of approximately 2200 F is pushed from one side into a quenching car on the other side. The car moves to the quenching tower where the coke is cooled by a spray of approximately 4000 gal of water. The coke is then dumped and later moved to the storage area.

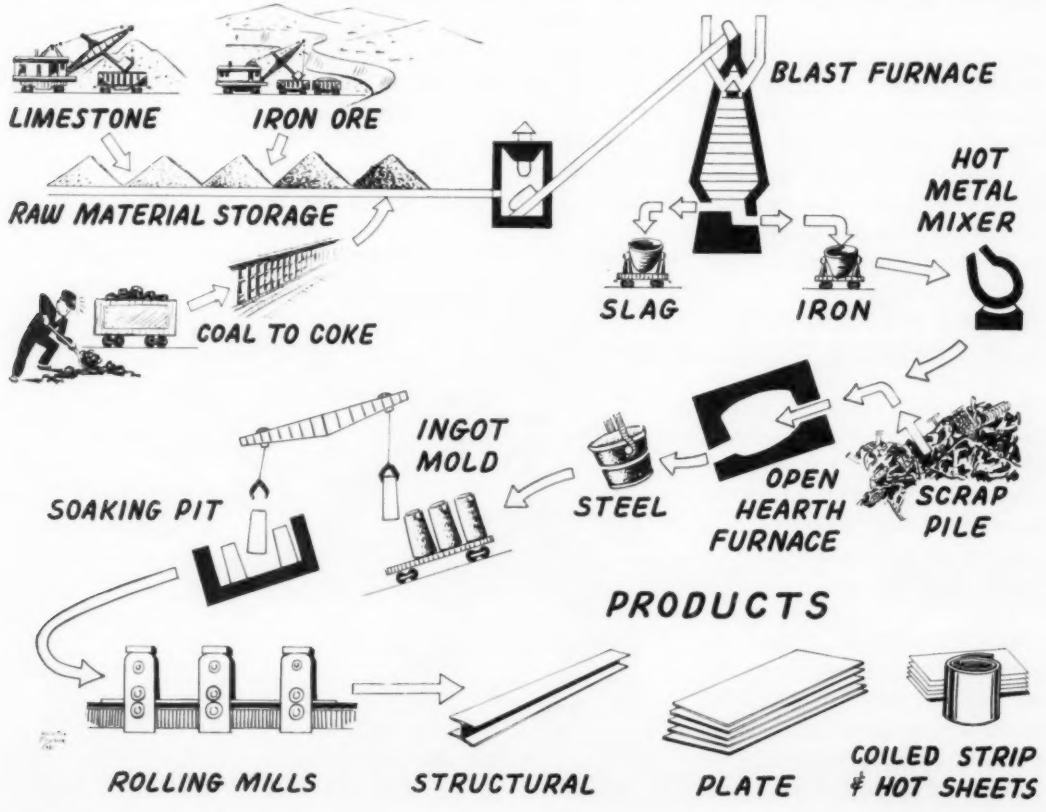


Figure 1 — Integrated steelmaking requires co-ordination of many manufacturing processes.

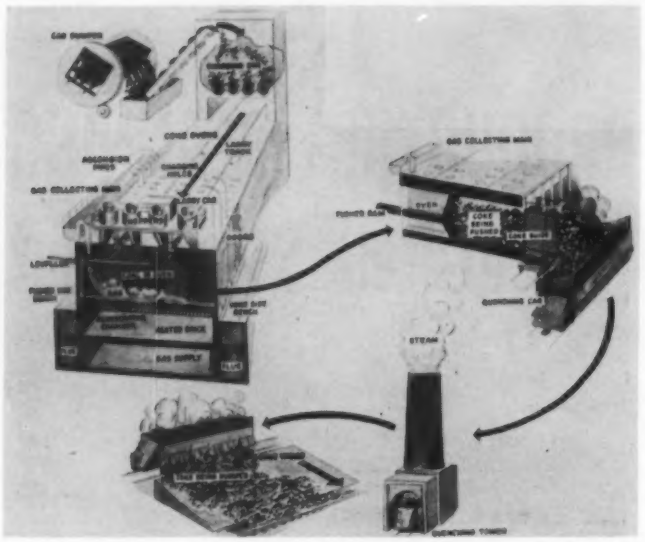


Figure 2 — The coke plant is essentially the domain of the chemical engineer. A wide variety of products are obtained.

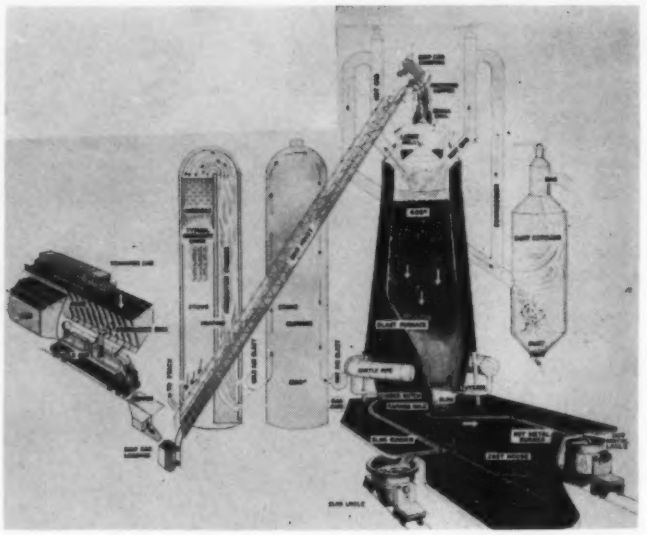


Figure 3 — The blast furnace is still "queen" in the integrated plant. Few manufacturing processes are as efficient.

In the blast furnace operations (Figure 3), the coke and other raw materials are carried to the top of the furnaces by the skip hoist. These materials are charged into the top of the furnace with the "burden," gradually moving down and the temperature gradually increasing from approximately 400 in the top to 3000 F in the bottom of the furnace. The slag or waste material is taken off on the left side and the metallic iron on the right. Iron is tapped or cast about four or five times each day.

Figure 4 is an over-all view of the steelmaking process. After hot iron, metallurgical limestone, steel scrap and other raw materials have been charged and carefully worked to exact chemical analysis and tapping temperature, the steel is tapped from the front of the furnace into a large steel ladle. The ladle is then moved by crane to the pouring platform, where it is cast or teemed into ingot molds.

Figure 5 is a view of just one of our three rolling processes. In this, our structural mill, blooms are charged into our reheating furnaces and brought to exact rolling temperature. They then pass through a series of rolls and are shaped into various zees, angles, channels, beams and other structural and bar shapes. In the finishing process, the product is straightened, cut to length, inspected and finally shipped to our customers.

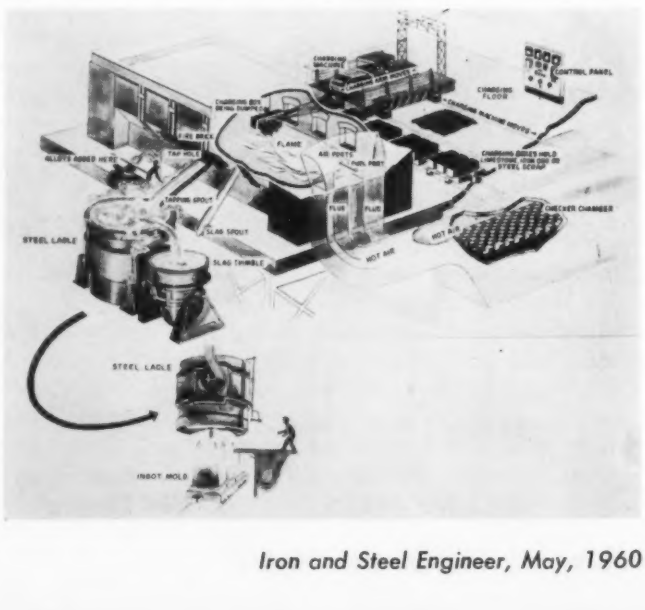
The remainder of this paper will show how production planning contributes to the over-all and maximum efficiency which is possible only when each of the separate producing centers and various staff units are working toward the same goal as part of a well-coordinated team. One of the factors that has contributed to continued outstanding performance at Geneva works is the principle that within our plant "each operation is a customer of the previous operation and demands the same quality and service standards we offer to the trade."

As a company grows in size, its over-all production and distribution problems become more complex. In our company, as in many others, this growth has brought about an organization with a large number of executives, in all phases of the business and at all levels of management. This is a far cry from the days, not too long ago, when many of our plants and divisions were individual companies or when the volume was such that some one or few managers could themselves control and co-ordinate all the operations of the company, personally resolve all differences and establish operating and/or sales objectives and policies.

As companies expanded their markets and became larger, specialists were hired to carry out particular aspects of the business. These specialists included experts in the fields of sales, quality control, industrial relations, engineering, accounting, operating, etc. The birth of what is now known as production planning in United States Steel came about in 1939, when executive management realized that the human tendency of sales people to primarily consider sales objectives and conversely of operating people to be mainly concerned with operating conditions and rates indicated the need for a single co-ordinating agency between the two (sales and operating) whose primary concern would be company objectives. This co-ordinating agency was one of the first instances of production planning, of any significant size, in any industry.

Production planning is a rather broad and general term. In a broad sense, production planning is the

Figure 4 — The open hearth dominates steelmaking.



method of developing programs based on known or anticipated sales demand assuring:

1. Optimum use of available facilities and manpower.
2. Sufficient inventories of raw material and semi-finished steel.
3. Efficient and adequate customer service.
4. The best possible profit situation.

Under this broad definition of production planning, the major functions are to:

1. Relate market analysis to production capacities.
2. Relate production costs to sales returns.
3. Control inventories (their economical and efficient use).
4. Relate customers' orders to planned schedules of manufacture.
5. Assure adequate and competent customer service.

These functions are part of every industrial company and touch all departments in the organization. The operating, sales, engineering, accounting and many other departments must contribute their knowledge and funnel information to the production planning department if maximum results are to be obtained.

There are, in our division, two separate and distinct levels of production planning. The first is the administrative production planning with headquarters in San Francisco; this level is mainly concerned with the division picture in the corporation and in the co-ordination of production, distribution and sale of products produced at the Torrance, Calif., works; the Pittsburg, Calif., works; and the Geneva, Utah, works. The second level is our own works production planning department.

First, let us take a look at the organization and the responsibility of the administrative production planning department located in San Francisco.

The division production planning organization is headed by a director of production planning, who reports directly to the vice president and assistant to the president. This organization is divided into two parts. We have a group headed by an assistant director—product co-ordination and a group headed by an assistant director—staff assignments. The product co-ordination group is primarily engaged in the day-to-day and week-to-week production planning activities which arise in the normal course of business.

The work of the staff largely consists of developing improved ways and means of carrying out the various production planning functions and in maintaining and issuing up-to-date production planning policies and procedures.

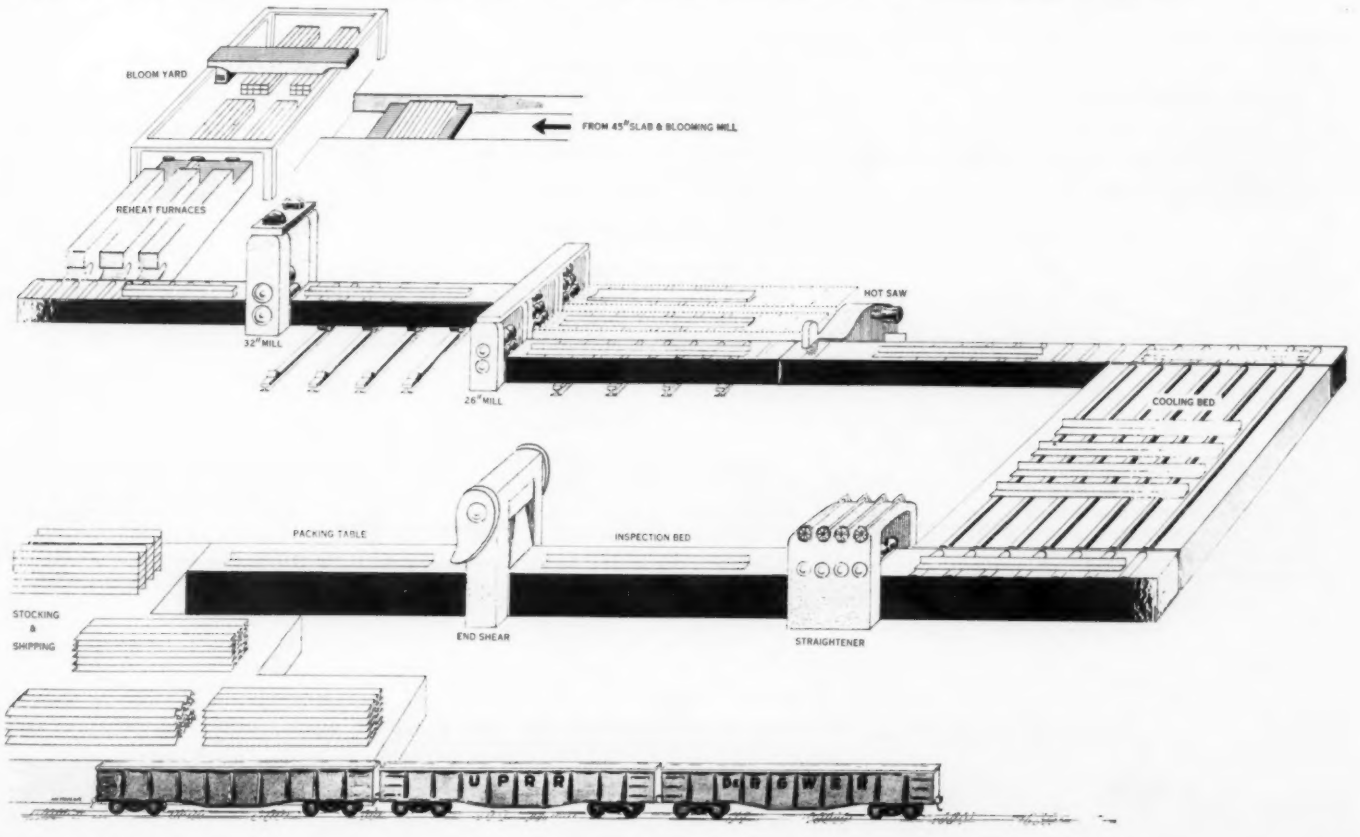
The responsibility of establishing, formulating and controlling production planning policies and programs for the division, and co-ordinating the activities of the production planning departments in the plants, are the major activities of the administrative production planning department. This includes the following functions:

1. Long-range planning—This involves the responsibility of assisting the executive management of the division in the formulation of long-range production and facility plans.

2. Short-range planning—The short-range planning is performed by establishing the "co-ordinated sales and production plan." We will discuss this phase of our activity in more detail later.

3. Order entry and service—Production planning is concerned with procedures and standards of performance in order entry, order service and establishing and maintaining sales and production objectives. In other

Figure 5 — The structural mill provides a wide variety of shapes designed to give economy in structures.



words, are the plant units giving the sales department the service they need to satisfy customers?

4. Facilities scheduling—To establish controls by which performance against the co-ordinated sales and production program can be currently ascertained, so necessary corrective action can be readily applied by sales and production executives.

5. Inventory control—This involves the control of semi-finished, in process and finished product inventories for the most effective order service and lowest cost of production.

6. Packing, marking and loading engineering—To develop the latest methods and procedures in this area and provide the plants with guidance and assistance in packing, marking and loading problems.

7. Procedures and systems co-ordination—This involves the responsibility for developing, co-ordinating and issuing all procedures dealing with entering, scheduling and servicing of all inquiries and orders; also, securing joint approval of all major departments involved, such as: sales, operating, accounting, traffic, credit, purchasing, etc.

8. Production and schedule control—The investigation and analysis of production bottlenecks and recommendation for corrective action.

The co-ordinated sales and production plan is the backbone of our division planning. Figure 6 shows the flow and major steps involved in short-range planning which may be defined as the process of determining for the immediate future which combination of products we are going to sell and produce. Our division's facilities permit a variety of products, but in a single production period any pattern once chosen excludes all others. The choice of such a pattern cannot be avoided. If we try to postpone this decision, our customers make the choice for us by the chance sequence in which they present their demands and by the aggressiveness with which they expedite. Rather than leave this production pattern to accident, short-range production planning anticipates what the situation will be and makes division decisions before we become committed to impossible or unprofitable combinations. Such decisions are the result of orderly and thorough advance appraisals of both sales and production possibilities. In our division, this process reaches down for its information into many departments. The administrative production planning department provides only guidance and a co-ordinating medium. The activity seeks primarily to find the most competitive and profitable production pattern for each period of operation. To do this, it must satisfy a maximum number of customers whom we expect to keep as customers. It must be within the possibilities of the physical equipment and must minimize costs at the same time that it aims at maximum proceeds.

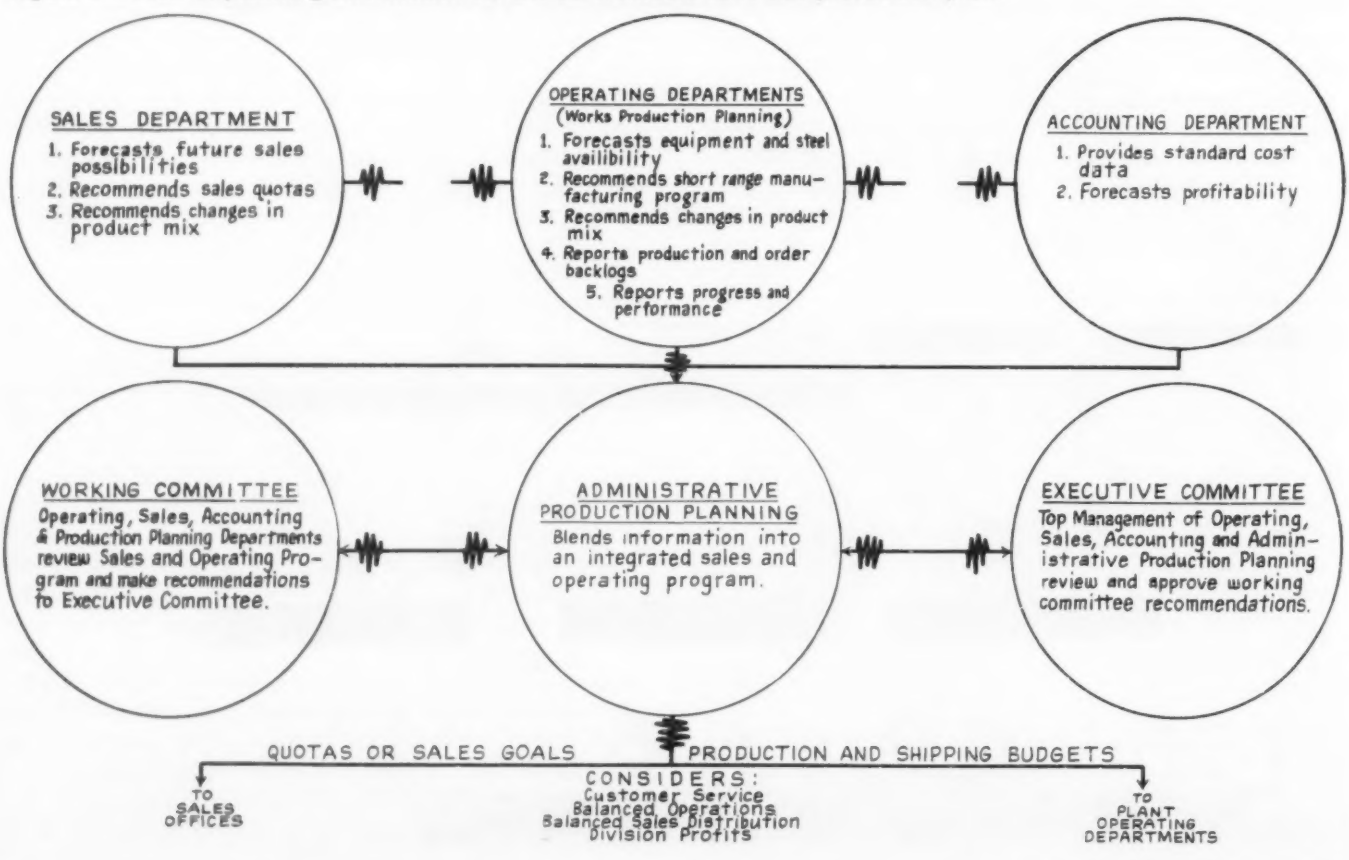
The management requirement for such a plan and the over-all system of bringing it together and acting upon it is called the "co-ordinated sales and production plan." Let us follow the essential elements and see how such a plan comes into being.

Our starting point is the sales forecast. From this forecast the people in division administrative production planning prepare a preliminary production program in full product detail covering a four-month period.

With the help of the accounting department, which provides standard cost data and forecast profitability, this preliminary plan is prepared with a specific knowledge of comparative profit and a general knowledge of the operating levels required.

The preliminary plan is then sent to the works where a complete review is made of the plan from the stand-

Figure 6 — Flow of planning information for the co-ordinated sales and production plan.


SALES DEPARTMENT
1. Forecasts future sales possibilities
2. Recommends sales quotas
3. Recommends changes in product mix
OPERATING DEPARTMENTS
(Works Production Planning)
1. Forecasts equipment and steel availability
2. Recommends short range manufacturing program
3. Recommends changes in product mix
4. Reports production and order backlogs
5. Reports progress and performance
ACCOUNTING DEPARTMENT
1. Provides standard cost data
2. Forecasts profitability
WORKING COMMITTEE
Operating, Sales, Accounting & Production Planning Departments review Sales and Operating Program and make recommendations to Executive Committee.
ADMINISTRATIVE PRODUCTION PLANNING
Blends information into an integrated sales and operating program.
EXECUTIVE COMMITTEE
Top Management of Operating, Sales, Accounting and Administrative Production Planning review and approve working committee recommendations.
QUOTAS OR SALES GOALS
PRODUCTION AND SHIPPING BUDGETS
TO SALES OFFICES
CONSIDERS:
Customer Service
Balanced Operations
Balanced Sales Distribution
Division Profits
TO PLANT OPERATING DEPARTMENTS

point of steel availability, operating rates, maintenance programs, inventories, crew availability, raw materials, steel balance, operating efficiency and many other factors. The plan is then returned to the division administrative production planning with the plant recommendations.

Now the plan is starting to take shape; we start with a sales forecast, and now against this forecast, we have the plant's recommendations. The division administrative production planning now resolves any obvious differences by collaborating with the sales, operating and other departments and by considering such factors as past and present performance and expected attainments, government regulations, and management policy decisions, and prepares a sound plan which meets the division objectives of sales requirements, operating requirements and an adequate profit return.

Quite often supply does not meet demand, this creates situations which cannot be easily reconciled, or sometimes impossible sales or operating demands require committee rather than arbitrary decision. To accomplish this, and in order to establish the best possible program, a working committee consisting of representatives of the plant production planning department, the administrative production planning department, the sales department and the accounting department meet each month and review the program recommendations. The committee examines every aspect of the program and either recommends the program to top management, as submitted, or recommends certain parts of the program with a request for top management decision on matters which could not be resolved at the working committee level.

The working committee chairman presents the proposed program and matters requiring resolution to the executive (top management) committee. This program includes a complete profit evaluation picture. From the executive committee acceptance and decision evolves a final program which guides the division's efforts in sales and production.

Now comes the task of putting the program into reality; this takes two main phases:

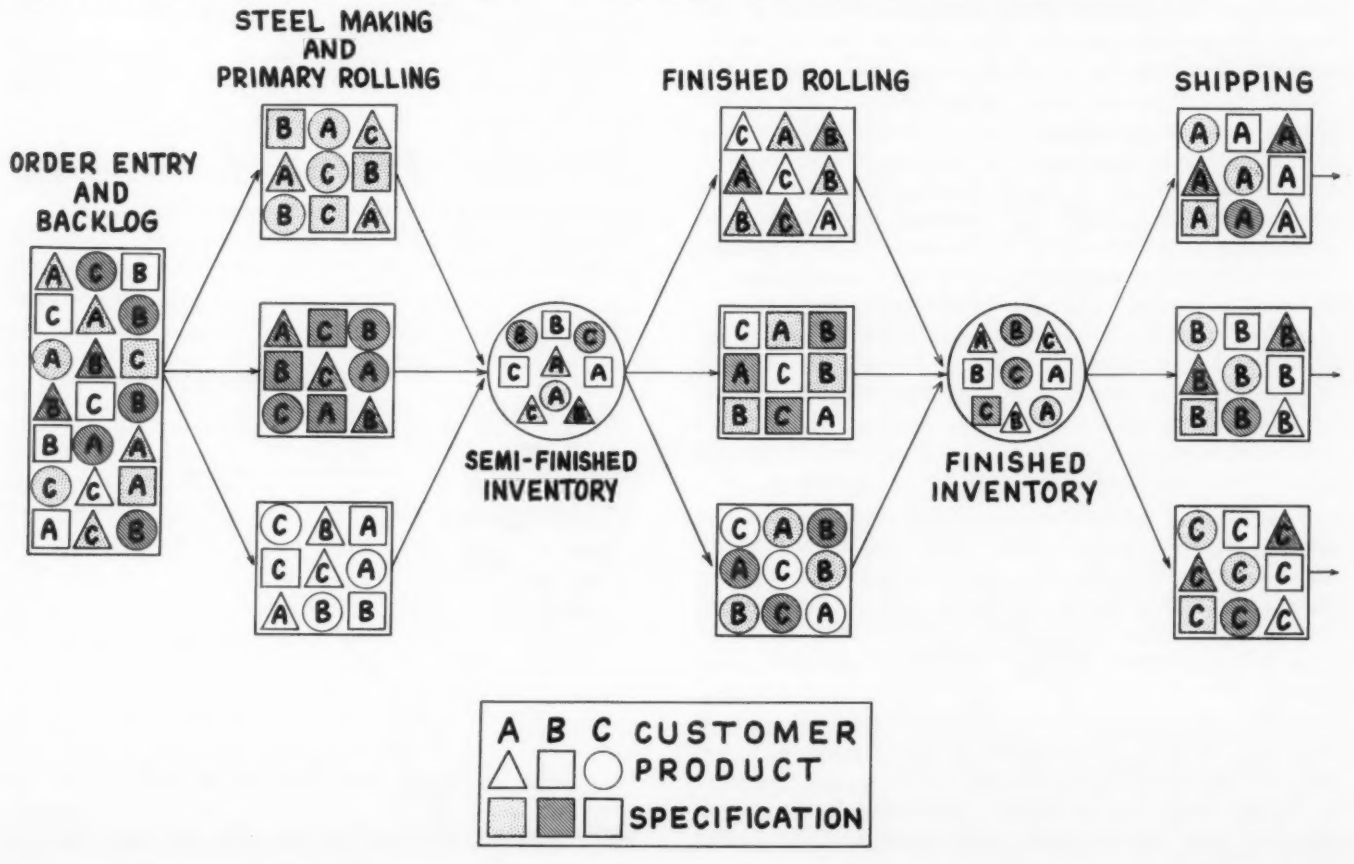
1. The distribution of the entry limits and/or solicitation objectives to the various plants and sales units and by the sales units to the various customers. The solicitation and procurement of customer's orders and the entry of these orders in sufficient time to execute proper schedules and operating rates at the mills so that the planned production and shipping goals can be met.

2. The receipt of sales orders at the plants and the backlogging and scheduling of these orders in proper production quantities in order to maintain maximum customer service and performance against the approved program.

The administrative production planning responsibility does not end with the distribution of the plan. They have a responsibility to follow-up and make a constant check on the progress of the plan. When conditions arise which affect the division's ability to reach the established objectives, the plan is changed, giving the interests of the customer and the division careful consideration.

At Geneva works, the production planning department is headed by a superintendent who reports directly to the general superintendent of the plant. In this organization, there are four major divisions. We have a group headed by a staff supervisor; a group headed by a general supervisor—service and shipping; a group headed by a general supervisor—providing and

Figure 7 — Proper scheduling is an important factor in profitable operations and service to the customer.



scheduling; and finally, a group under the direction of a supervisor of blast furnace and coke plant products. Two of the groups are further sub-divided by function and/or product, and each sub-division is headed by a supervisor.

The major responsibilities of works production planning are as follows:

1. To recommend short-range production plans for the works, comprehending the most economical utilization of facilities based on current order backlogs, sales forecasts, current and desired inventories and balanced product mix.

2. To assist works management in the formulation of long-range production plans involving the most effective layout and scheduling of new facilities.

3. To execute established controls related to semi-finished, in-process and finished inventories for the most effective order service at the lowest cost of production.

4. To receive, process and service orders and inquiries.

5. To schedule plant production facilities.

6. To plan shipments.

7. To execute established controls by which the works performance against the co-ordinated sales and production plan can be currently ascertained so that necessary corrective action can be promptly taken by works and/or division management.

8. To participate in the development of and subsequent administration and adherence to all division and works' procedures dealing with the entering, scheduling and servicing of all inquiries and orders.

9. To act as point of contact for all authorized parties on all order service matters.

10. To investigate and analyze production bottlenecks and to recommend corrective action.

Because scheduling is such an important function, we would like now to illustrate the principle under which production scheduling is handled.

In Figure 7 the different shapes indicate the many products which our works makes. The different letters are indicative of the fact that various customers buy our products and the cross hatch represents the numerous specifications which are ordered. From this material, plus a considerable number of additional details which have to be considered, such as, customer delivery requirements, quotas, government regulations, inventories, production bottlenecks, optimum providing practices (Figure 8), mold sizes, ingot heights and yields (Figure 9), etc., the schedule clerk has the job of combining like elements to satisfy the needs of our equipment and crews, and at the same time meet the competitive delivery commitments to our customers.

Note that in steelmaking, items of the same specification, depicted by the cross hatch, are combined to make a heat. From the standpoint of production flow, there is movement into inventory point where, to a certain extent, there is a mixing again of different products, different specifications and steel for different customers.

In the rolling operation an entirely different arrangement has to be made. Here items of the same product shape must be grouped together. The groupings are, of course, only one of many, many factors that the schedule clerk has to consider in laying out an actual

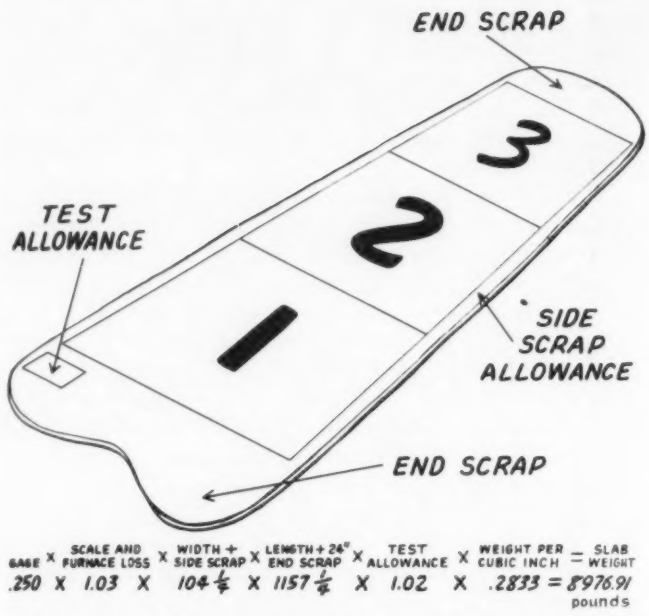

END SCRAP
TEST ALLOWANCE
1
2
3
SIDE SCRAP ALLOWANCE
END SCRAP
GAGE × SCALE AND FURNACE LOSS × WIDTH + SIDE SCRAP × LENGTH + 24" END SCRAP × TEST ALLOWANCE × WEIGHT PER CUBIC INCH = SLAB WEIGHT
.250 × 1.03 × 104 1/8 × 1157 1/8 × 1.02 × .2833 = 8976.91 pounds

Figure 8 — In plate providing, allowances must be made for scrap and other losses. Overallowances result in waste.

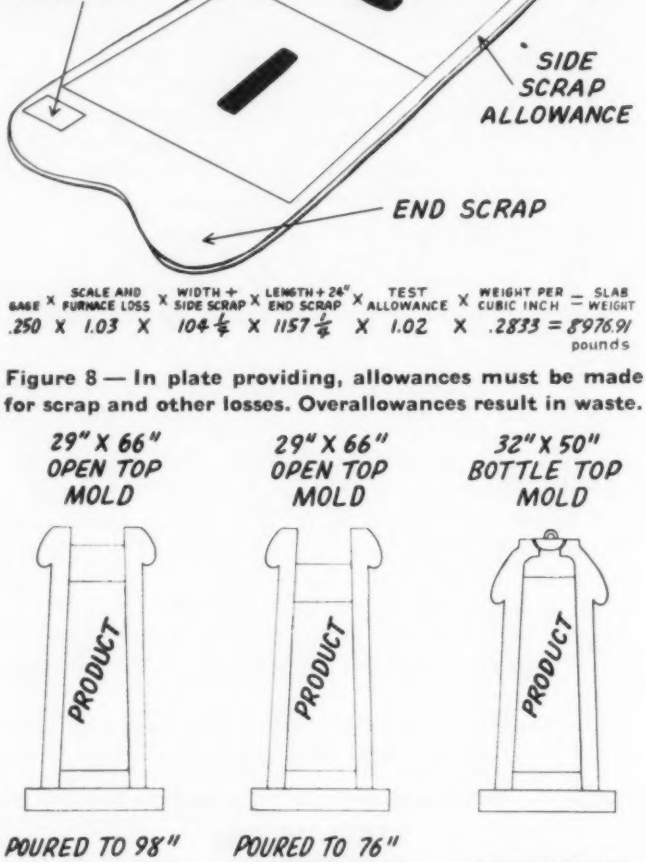
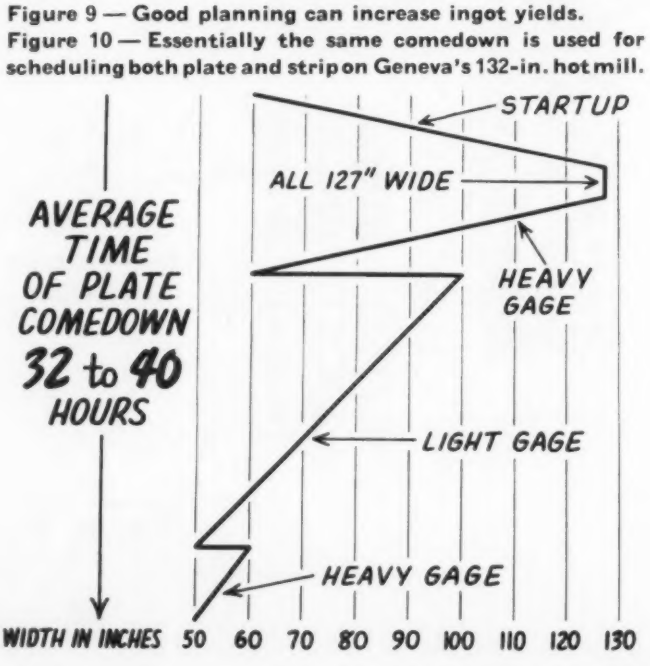


Figure 9 — Good planning can increase ingot yields.

Figure 10 — Essentially the same comedown is used for scheduling both plate and strip on Geneva's 132-in. hot mill.


STARTUP
ALL 127" WIDE
HEAVY GAGE
AVERAGE TIME OF PLATE COMEDOWN 32 to 40 HOURS
LIGHT GAGE
HEAVY GAGE
WIDTH IN INCHES 50 60 70 80 90 100 110 120 130

detailed sequential rolling schedule for a particular mill.

Here again, there is a mixing of various products and various specifications into a finished product inventory and now another grouping into shippable quantities for particular customers.

In appraising the results of our production and shipment scheduling activity, we must keep in mind that striving for the highest in customer service at the lowest operating cost is a never ceasing job. To obtain maximum proficiency and meet the necessary standards, the scheduling function must be handled with the utmost effectiveness and co-ordinated with all departments in the plant, and, in addition, requires that order changes and preferencing appeals be held to a minimum to avoid disrupting established production lots and schedules.

Here now are a few of the major planning problems at Geneva works. We will touch on some problems that exist in any fully integrated steel plant and on others that are peculiar to Geneva works.

Good production planning provides the co-ordination required so that all departments can work together effectively and economically in satisfying customers' service and delivery requirements. It is of greatest value when production is not as planned, for it is in these periods that greatest risks to maximum production, minimum costs and optimum customer service exists. Production planning is adequate only when needed schedule and production changes can be made successfully and in an orderly manner, with full anticipation of all of the major factors which influence plant operations unnecessary costs and optimum customer service and promise performance.

The first step in the steelmaking process where plans can go astray, omitting the many, many problems that can occur in our mining, raw materials and iron making process that come before this step and also sometimes cause us to change plans, is in the Geneva works ten open hearth furnaces. Here a blending of hot metal, pig iron, broken molds and stools, steel scrap and other raw materials carefully worked for a period of from ten to twelve hours normally result in the production of a perfectly balanced heat of approximately three hundred tons. Sometimes, however, something goes wrong; it may be off-chemistry, caused by excessive re-carbonization, a soft melt caused by a low carbon content, excessive mold additions resulting from over-oxidation, an excessive skull, a forced tap, high sulphur content in the iron or anyone of a dozen or more conditions.

Usually a combination of a number of customers' items and sometimes a mixing of finished steel products are required in building up this single heat quantity. Now that we have lost the heat, as planned, our problem is two-fold. First, we must attempt to keep the ingots moving as hot steel through the production process by application to other orders in schedule, or in the backlog, or by anticipating future requirements. Although sometimes these applications disrupt normal schedule sequences, they result in maximum operating efficiency and division profits. Second, we must reorder the heat from the open hearth in sufficient time to maintain finishing mill schedules and meet customers' delivery promises.

A short cut slab is another situation that disrupts schedule sequence. The short slab will be applied to another order in schedule or put into miscellaneous slab stock for future application. At the same time, every effort will be made to provide another slab attempting to meet our delivery commitment—thus permitting our customer to maintain his schedule plans. Full ingots may also be lost from the current schedule when we have what we call a "sticker"; here, the ingot freezes in the mold and sometimes a change in the weight and size of the slab, caused by cutting away defective portions in the slab yard, also causes rejection from the current order.

One of the situations that is peculiar to Geneva works is the rolling mix on our 132-in. hot mill where we produce both plate and strip products. The rolling cycles give us a very short period to get rolling replacements back on the mill during the schedule week. In Figure 10 one can see the general arrangement of a plate comedown on the mill. Essentially the same scheme is used for strip comedowns. Plates for different customers and order items are often combined into a single slab in order to obtain maximum yield and operating performance.

In the finishing process where the plates are leveled, marked and laid out, cropped and sheared into shorter lengths, the sides are trimmed and the ends sheared to exact ordered dimensions after which they are inspected, piled and transferred to the dock to await shipment to the customer. Here we have another problem peculiar to Geneva works; the production rate of the 132-in. mill in rolling plate product averages about double the rate per turn of the average finishing turn rate. This production rate difference requires that many plates be taken off the finishing line and floored when plates are coming off the mill. It also requires that the finishing operations work a 15 to 20-turn schedule in order to take the output of the rolling mill working an 8 or 10-turn plate schedule. A split finishing flow causes many of our items to travel in different directions in small lifts and requires that we bring them back together again for efficient warehousing and shipping practice.

The production planning department maintains complete postings of production and rejections against each order, and they constantly expedite material in process and provide for immediate replacement of rejects to avoid missing customer order commitments. It is important that shipments be scheduled in proper promise sequence consistent with efficient and economical operating practice. In addition, our shipping group must be sure that they do not schedule a partial shipment on a particular customer's order without anticipating how they are going to ship the remainder.

Customer service is one of production planning's major responsibilities, and our answers to sales questions must be complete and reliable with as few excuses for failures as possible. Production planning works with all departments for continued sound customer relations by supplying the very best in quality products at a fair price, and aiming for the highest standards of production and promise performance coupled with reliable, accurate and prompt order service information. We believe that our customers have every right to expect this, and we in United States Steel and at Geneva works, are doing our utmost to attain nothing less than 100 per cent performance in these fields. ▲

Auxiliary Drive Static Rectifiers

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. . . . major gain from using new automatic systems is the improvement in product quality because of better process control . . . . this in turn gives larger savings to the manufacturer because of increased percentage of prime product . . . .

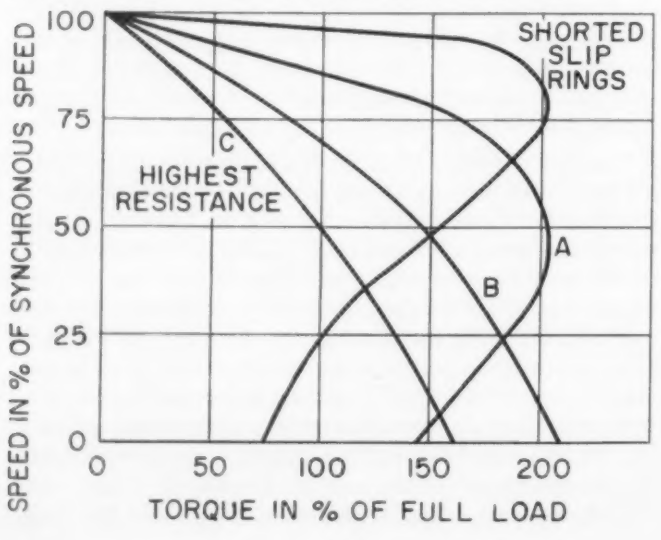
THE subject of auxiliary drive static rectifiers includes a wide field for discussion. This paper covers this subject as it is applied to a new standardized drive which incorporates desirable features making it suitable for use with many heavy industry auxiliary drives.

For many auxiliary drives the a-c motor is entirely satisfactory. The most economical in terms of horsepower per dollar is the 3-phase squirrel cage motor. On constant speed application where starting torques are not excessive the squirrel cage motor may be the proper driving unit.

Slip ring a-c motors may be used for some drives when increased starting torques are necessary. Curves in Figure 1 indicate how the torque at zero speed can be changed by changing the external resistance connected to the slip rings. The top curve, with the slip rings short circuited, is similar to the speed-torque curve for a squirrel cage motor. These curves show a peak torque of about 200 per cent of full load torque. The peak torque may vary somewhat depending upon motor design. It should be noted, that the family of curves all come together at 100 per cent synchronous speed at zero torque. The flat portion of each curve above the speed shown for its peak torque value, may be considered the working range. Note how the slope of the working range portion of the curves increases as resistance is added to the motor secondary. A steep sloped curve such as curves B or C indicates that the motor speed changes greatly with changes in load.

Machines on which the load may vary or require operation at various speeds must have a power drive

Figure 1 — With wound-rotor motors, speed-torque curves can be changed by changing secondary resistance.



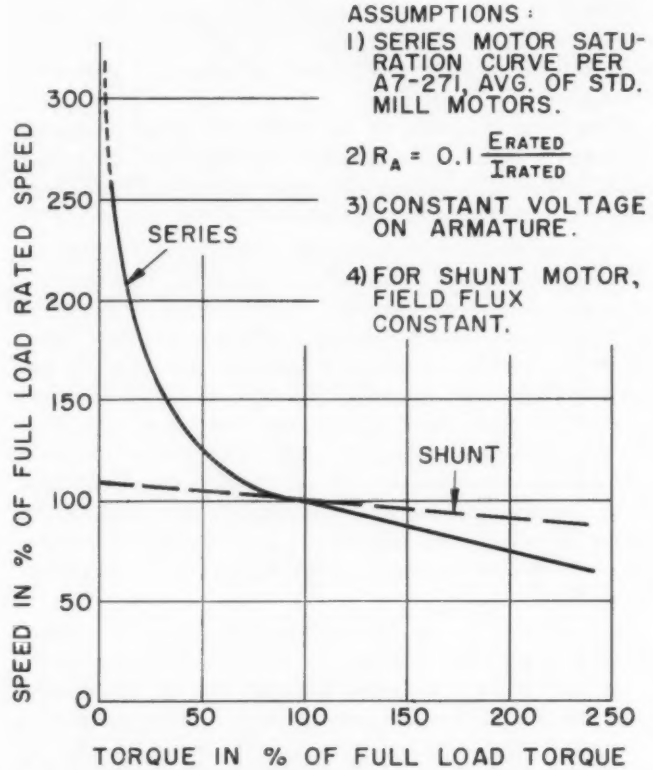
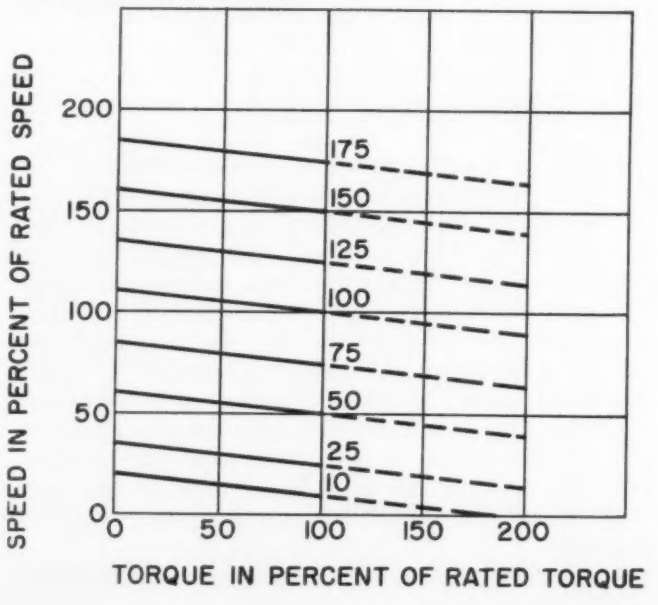


Figure 2 — Speed-torque characteristics of d-c motors lend themselves to relatively easy speed control.

Figure 3 — With adjustable-voltage control, a wide range of speed characteristics can be obtained on d-c motors over a wide range of loads.



that can be controlled or regulated to fit these requirements. The characteristics of an a-c motor may not be satisfactory for many of these applications. When a-c is the only power available, the characteristic of the driving unit is sometimes modified by using a mechanical speed changer, an electrical or hydraulic slip coupling or a hydraulic variable speed transmission. A multispeed motor or even a special variable speed a-c motor is sometimes used.

All of the foregoing methods plus other arrangements for many a-c motors on adjustable speed applications have been used. It seems no basic system has been adopted as generally satisfactory for most applications.

A d-c motor has one basic feature that makes it an excellent choice of drive for most adjustable speed applications. That feature is that its speed can be controlled.

Everyone familiar with d-c motors knows the two basic types are distinguished by their field winding, series-wound and shunt-wound. Also, it is well known that the shunt-wound motor speed torque characteristic is substantially flat as compared to the series-wound type. This is displayed in Figure 2.

The motor with the flat characteristic is preferred for applications requiring a constant speed with varying loads. A good way to obtain a family of curves which are parallel, is to apply different voltages to the armature of a shunt motor. In this manner the motor may be controlled to run at different speeds and for each voltage setting the speed will be comparatively stable over a wide range of loads. This is shown in Figure 3.

A common method for providing adjustable voltages for the armature of a d-c motor is to use a motor-generator set. The generator is usually driven by a constant speed a-c motor. The speed of the d-c motor is controlled by the generator voltage which is varied by regulating the generator field excitation. Some of these systems can become quite elaborate to satisfy the requirements of operation. Basically, this method for providing an adjustable voltage supply for the d-c motor involves the disadvantage of requiring additional rotating machinery.

Static dry type rectifiers are used for many purposes where it is desired to obtain d-c power from an a-c power source.

Over a period of years, improvements have been made in rectifiers which have greatly extended their fields of application. One important development brought about as a result of improved rectifier characteristics is the magnetic amplifier. To make this new device practical, the steels used for the reactor cores in magnetic amplifiers, have been improved to obtain the desired magnetic characteristics.

A magnetic amplifier consists of one or more reactors connected in combination with rectifiers. Each reactor is provided with gate windings and one or more control windings. Alternating current is applied to the gate winding circuit. The output of this circuit is supplied to the load through rectifiers so the load is energized with direct current. The magnitude of the d-c output voltage may be regulated by controlling the current in one or more of the separate control windings. The control windings are energized with direct current. By this system a large quantity of power supplying the load may be controlled with a relatively small amount

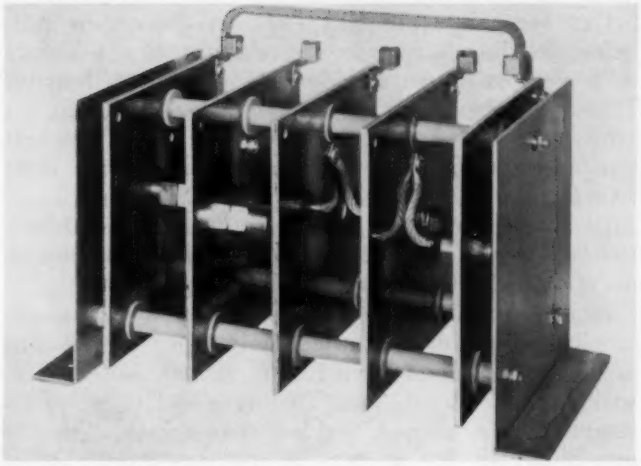


Figure 4 — Silicon rectifiers are used in the power magnetic amplifier assembly.

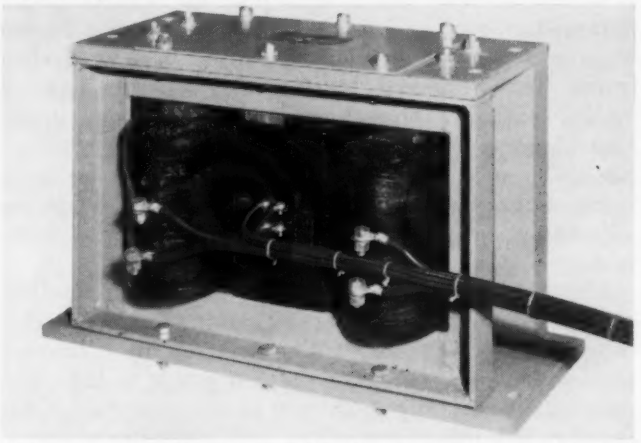


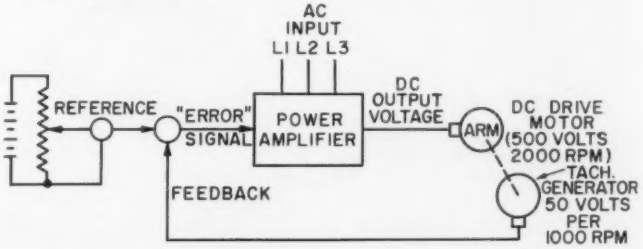
Figure 5 — Reactors assembly is mounted in rigid steel frame.

of control power. The over-all operation is very much like that obtained with the conventional motor-generator set.

Magnetic amplifiers are employed for many purposes and have proved to be an indispensable component of electrical equipment for application with critical regulating requirements.

One of the recent factors which helped to expand the use of magnetic amplifiers was the improvement made in silicon rectifiers to make high voltage, high current cells commercially available. Compared to selenium the silicon cell is considerably less bulky, has an efficiency in excess of 99 per cent; whereas, the selenium diode has a maximum efficiency of 87 per cent. Silicon diodes have exceptionally low reverse currents so that almost all of the power loss is due to the forward current. Silicon diodes may be operated at a case temperature of 150 C. Convection cooling for the diode is provided by assembling the diode on fins which increases its ability to carry higher currents.

Figure 6 — Schematic for static magnetic amplifier speed regulating systems.



Our company ran field tests on these new cells before deciding to use silicon diodes instead of selenium in a new static adjustable voltage packaged drive. These tests have proved that the silicon cells do not exhibit the aging characteristic of selenium cells. It also appears that the rectifier life expectancy is at least as great as that of the reactors.

Of a new line of packaged adjustable speed drives, two basic types are available, one is a magnetic amplifier type, and the other is an electronic type.

Silicon rectifiers are used for the power magnetic amplifier assembly in the magnetic type. The reactors are high gain units having tape wound, sawed cores with bobbin wound coils. The cores and coils are assembled in a rugged, welded steel frame. The life expectancy of the reactors is comparable to that of power transformers.

Figure 4 shows the assembly of the silicon diodes mounted on cooling fins in conventional stacks. Figure 5 shows a reactor assembly mounted in a rigid steel frame. Three separate reactors and separate rectifier stacks, similar to those shown, can be postioned on the control panel for most effective component arrangement. These static, space saving units are the main parts of the power conversion assembly to provide the adjustable d-c voltage to the armature of the shunt motor.

The block diagram in Figure 6 shows a simplified circuit for such an adjustable voltage system. This shows the power amplifier energized from the a-c lines with its d-c output supplying power to the drive motor. The d-c output voltage of the power amplifier may be adjusted to any value, within the preset limits, by changing the reference voltage. Motor speed is a function of the applied armature voltage. The voltage of the tachometer generator varies with the drive motor speed. By feeding the tachometer generator voltage back to the reference voltage system, a voltage may be obtained which is a resultant of the two voltages. This resultant voltage or "error signal" is applied to the control circuit of the power amplifier to regulate its output voltage so the drive motor will run at the speed called for by the setting of the reference voltage regulator. The standard drive uses a voltage taken from the power amplifier output for feedback instead of using a tachometer generator for that purpose. Current limit acceleration and IR drop compensation may be included in the basic circuit.

A complete packaged adjustable speed drive includes an enclosed controller and power conversion unit, a separate operators station and the d-c drive motor. Figure 7 shows the front view of a reversing type drive for two motors. One motor is for the forming rolls and the other for the sizing rolls of a tube mill. Current limit acceleration, field loss protection and accelerating and decelerating field relays are included in addition to main fuses and overload protection. Notice the flexibility of mounting arrangements for the components, especially the power reactors at the bottom of the case. Two of them are mounted side by side and the third is located back of these two. In order to reduce the width of the enclosure, the power rectifiers are mounted in the rear as shown in Figure 8.

An important point favoring the use of a static power packaged unit of this type is the fact that its dimensions may be proportioned to fit into locations which may have space restrictions in any of three dimensions. The power reactors and rectifiers may be mounted separately from the control panel in any configuration to satisfy the physical arrangement of an installation. No special mounting foundations are required and critical alinement problems are absent. The reactors and rectifiers are often mounted to advantage on top or on the rear framework of a preassembled control panel. Installation time and costs are thereby reduced.

Because these power packages may be built in one unit or separated into smaller sections they may be placed in the most convenient location for any installation. It is not necessary to provide special rooms or air conditioned areas. Increased use of these static power packages should contribute to the reduction of future motor room space requirements. Areas with high unused head room are not required. Static units are silent operating as there is no vibration to cause noise.

A comparison of the physical factors between the magnetic static package including the power rectifiers and reactors with average values for rotating type power packages is shown in Table I. This indicates that the area, volume and weight of the 50-hp size is more than 25 per cent less than the rotating type power unit and more than 50 per cent less for the 100-hp size.

The characteristic curve of this power package is very similar to a generator excitation curve. The conventional regulating methods that are applied to generators can also be applied to these units. The efficiency of these units at full power output is above 95 per cent. This compares with efficiencies in the order of 80 to 85 per cent for the motor-generator set. Being a static device with no moving parts, there are

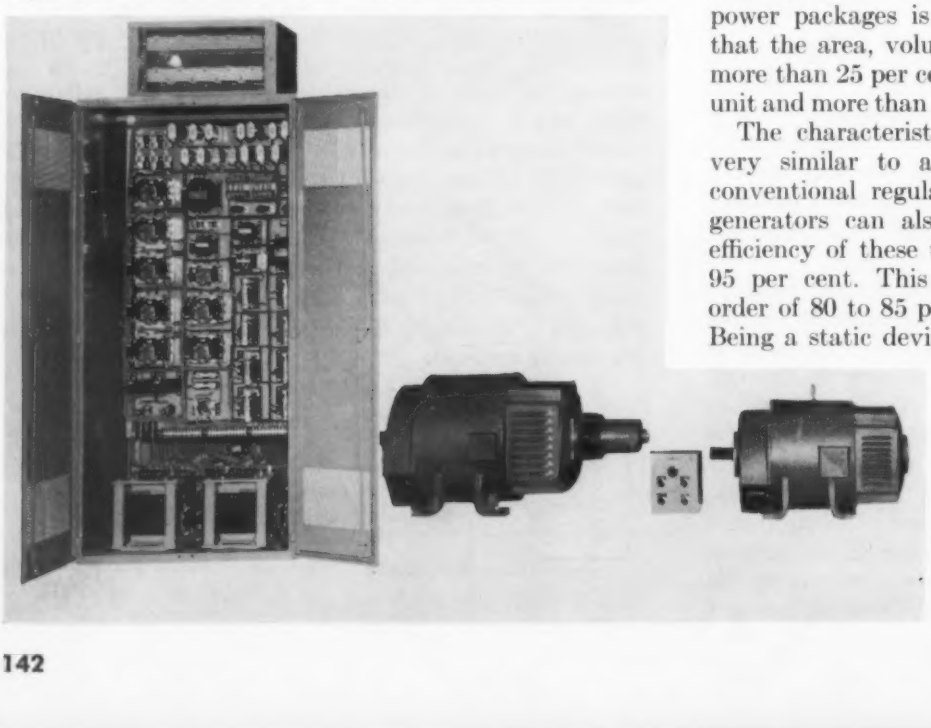


Figure 7 — This 50-hp drive is used for forming and sizing mill on electric weld tube mill.

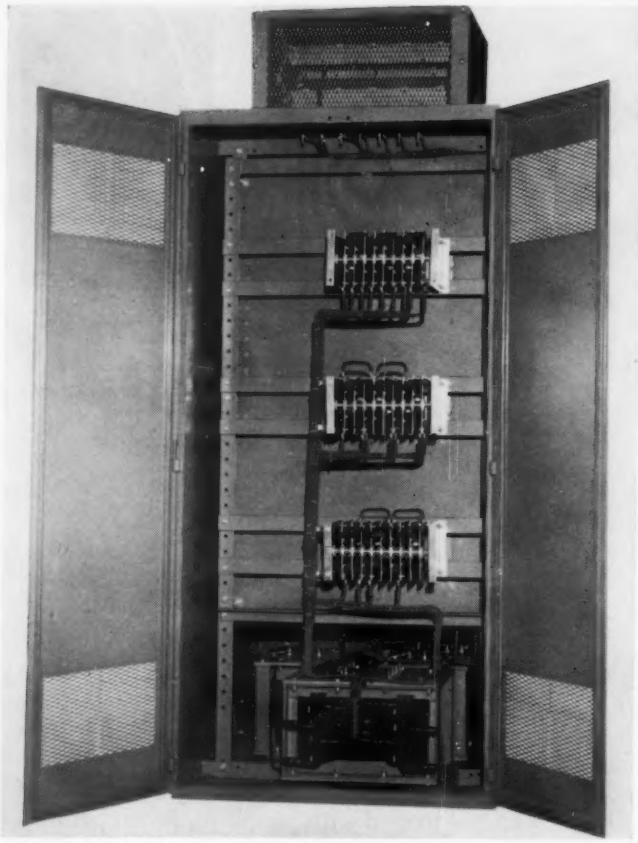


Figure 8 — Power rectifiers are mounted in the rear of the 50-hp drive panel.

no mechanical losses. More efficient use of iron and copper in the static assembly reduces electrical losses.

Because of the unilateral nature of the output current, the unit cannot absorb power from the motor. Applications with high inertia loads requiring rapid slowdown and loads with regenerative power cycles must be provided with means to absorb this energy. Resistor loading may be used to absorb this power.

Packaged adjustable speed drives using power magnetic amplifiers with all the desirable features mentioned make them suitable for a great variety of mill auxiliary applications. Reversing or nonreversing drives requiring a wide speed range of operation may be provided. All the usual regulating methods and protective features included on standard constant potential and adjustable voltage type mill controllers may be obtained.

Such packaged magnetic drives are being applied to tube mill main and sizing rolls. Other applications are for wire drawing machines, drawbench, sinter machine feeders and main drive, recoiler and slitter. Levellers, tables and kickouts might also be powered by these units. Locations where only an a-c supply is available, but where d-c motor characteristics are desired may use one of these adjustable voltage power conversion units at quite a saving in over-all installed and operating cost.

Static type power equipment has proved to be a very important and dependable part of electrical powered drives for all industries. Some advantages of using static type equipment for providing adjustable voltage power supplies were briefly described in the foregoing. These comments, no doubt, may bring to attention other applications where magnetic amplifier packaged adjustable speed drives may be used to improve machine operation, reduce first cost and operating costs.

TABLE I
Comparison of the Magnetic Static Package Controller Including the Power Rectifiers and Reactors with Average Values for Rotating Type Power Packages

	Floor Area, sq ft	Volume, cu ft	Weight, lb
50-Hp			
a. Rotating type	17.8	105	2980
b. Magnetic static	11.7	70	2200
"b" less than rotating type by per cent	34	34	26
100-Hp			
a. Rotating type	25.2	158	5700
b. Magnetic static	11.7	70	2400
"b" less than rotating type by per cent	53	56	58

This discussion has regarded the utilization of a new and improved product. Although we feel that the magnetic drive offers great advantages and significant improvements to the art of adjustable speed drives, we are also confident that it is not the ultimate device for this application. Already, new and improved rectifier materials, including controlled rectifiers, are on the market in small power sizes. As the state of the art advances, as it is doing rapidly in the rectifier field, we are sure that even better static drives can be built at more and more economical costs. Once the gate control rectifier is available in large power sizes, we will be able to eliminate completely the magnetic reactors presently used in the drive and obtain our entire voltage control in the rectifier cells alone. One can appreciate the tremendous size and weight savings available to these drives through these new type rectifiers.

At the moment, these new rectifiers cost slightly more than their weight in gold but this situation is certainly subject to change and, in a very few years the use of these new devices will be completely economical.

To a large extent, the use of static devices in the switching and control of electric power is a direct result of the tremendous expenditures being made by our defense department for advanced scientific investigation.

The major gain from the utilization of new automatic systems will be the improvement in the quality of the product produced in the controlled process. Big savings are available to all companies and, in particular, to steel companies through the increase in the percentage of prime product. These new automatic systems will produce a greater percentage of prime product through more consistent control of the operating variables. Many of the new devices we have seen will make possible the continuous and high speed measurement of many quantities that it has previously not been possible to measure. The electrical industry has demonstrated in past years that once it can successfully measure a quantity it can readily control it. Therefore, we are extremely enthusiastic over the ability of our industry in the next few years to build significantly improved drive and control systems for all industries and, in particular, the steel industry. ▲

by HARLESTON R. WOOD,
President,
Alan Wood Steel Co.,
Conshohocken, Pa.

Engineering—

ENGINEERING and politics, or management and politics or anything else and politics cannot be separated for, in a broad sense, there is politics in everything we do—in our home life, our clubs, in engineering or any other kind of work.

Sometimes machinery is not successful for political rather than strictly engineering reasons. Many engineers have had the experience of designing a machine which would not work because people would not try hard enough to make it work. Also, we have seen many machines which were designed so that they would work, but only if they were operated by people with almost superhuman intelligence or conscientiousness. Sometimes we see machines which are not successful because they are being operated by three men when they were designed to be operated by two, or which are being operated by two men as planned, but with the addition of one maintenance man who was not contemplated by the designer.

Another thing we see all too frequently is a machine which is capable of performing its task, but which is not doing so because the men who are operating it have decided it would be to their advantage not to let it. Perhaps they are waiting for the establishment of an incentive rate which is satisfactory to them; perhaps they are holding out until a supervisor they do not like is fired; or perhaps they have decided for reasons of their own that they are never going to let it work.

In these instances, the fact that the machine does not operate as planned may have nothing to do with mistakes which were made with a slide rule. It does, however, usually very definitely have something to do with the fact that at the time the machine was designed, someone—either the engineer or someone else—failed to comprehend the political environment in which the machine was to operate. Someone failed to investigate the human factors and to make plans to satisfy them so that they would not prevent the machine from performing its task.

When this happens to an engineer, he has a choice of two things:

1. He can maintain his position, say that he is an engineer; that he did his part of the job; and someone else prevented his fine machine from functioning the way it should. Having said this, he can then continue to draw his pay and to sulk in the engineering department awaiting the discharge of those who are preventing his work from being appreciated, or he can resign and try and find a more "reasonable" company or person to work for—a place where someone else sees to it that politics does not prevent his machine from working. (There have even been instances where scientists have defected from the Free World and gone behind the Iron Curtain for this reason.)

2. The other thing he can do is decide that he—as an engineer—must look more closely at the human element and the political environment before finalizing his design. You might almost say that he has to operate as a psychologist as well as an engineer. He must take into consideration viewpoints of other people and design his machine so that it operates in spite of their shortcomings or prejudices.

If we look around us, it is easy to see that the successful engineers—those who are accomplishing the most and are earning the most—have selected the second of these two choices. They have broadened their activities beyond pure engineering. They are using tools other than slide rules—tools which were not designed specifically for engineers, but which were designed for the use of everyone who has to deal with people and with political situations.

In other words, they have combined their special engineering knowledge with a knowledge of how to get along with people so that they can build machines which operate efficiently.

How do we go about it if we are an engineer and wish to insure our designs against failure due to human or political factors?

Let us start out at the beginning. In designing a machine we would normally proceed through the following steps:

1. Determine the objective—what we wish the machine to accomplish.
2. Write a job description for the machine—a description of exactly what we wish it to do.
3. Establish a performance standard for the machine—how well and how fast we wish it to perform its job.
4. Appraise the performance of the machine after it is in operation—ascertain just how the machine might be improved and feed this information back to the engineering department for design of improvements.

This is the cycle that most of us use to get the best possible performance out of either a machine or a person. It is frequently referred to as the "Management Formula."

These are the steps which should be taken, but how we take them and whom we include in them is of extreme importance. In large corporations, a formal organization chart and written procedures outline how the steps are to be taken and who is to be included in each phase of the cycle. In effect, a political machine is set up to give us the maximum chance of success in dealing with the human or political factors we encounter.

This political machine includes all of the persons who are interested in the performance of the machine we are trying to design. In addition to the engineer, it will include those who must operate the machine, the indus-

Management—And Political Machines

. . . . feature address given at informal stag dinner, AISE Annual Spring Conference, Philadelphia, Pa., April 26, 1960 . . . .

trial engineers who must set incentive rates for the machine, possibly the production controller who must schedule the machine, the salesman who must sell the output of the machine, the accountant who must measure the profit the machine earns for us and many others.

These people must be included from the very beginning if our political machine is to be a good efficient one. They must participate in every step of the cycle we use to design the machine. The engineer must compromise with them as we go through these steps. In many instances, he must do things which are not correct from a strictly engineering standpoint in order to make sure the machine being designed will have the best chance it can have to operate efficiently.

For instance, the financial people may point out that it is necessary to reduce the cost of the machine so that we can make money on the investment. We may need the 90 per cent perfect machine at 50 per cent of the cost of the perfect one for this particular job.

Or, we may need to abandon our pet control feature because it is one more instrument than the operators feel reasonable to expect a man to keep his eye on.

Or, the sales department may point out that the product we are going to get through engineering perfection will not be appreciated enough by customers who prefer something more simple.

When an engineer makes a compromise of this type, he is making it easier for the management of the company as a whole to perform its task although he may be adding to his own work.

He is becoming what is known as a "company man"—or someone who puts the over-all good of the company ahead of his own professional pride or prestige.

The "company man" is very much in demand nowadays. Everyone wants the man who can become a member of the political machine which is running the company and give it his wholehearted support. There is considerably less demand for the man who strives for technical perfection in his own field and ignores the needs of those in other departments. These lone wolf geniuses—or dissenters from the organization—have sometimes in the past accomplished much, but in modern day society their value is decreasing.

Life is becoming more complex everyday. Machines have become more complicated. It takes thousands of engineers to design a plane or a rocket. The chief engineer becomes more and more a manager or coordinator of engineers working for him. This has proceeded so far that in many instances his technical knowledge is of very secondary importance.

The same thing is taking place in all the other departments in our corporations, and the result is that almost everyone in a responsible position must be a broader person than was required in past generations.

We who occupy management positions now must face pressures which are far beyond the power of anyone in our companies to control—pressures which were undreamed of by our grandfathers. Our Government—National, State and Local—tells us what we must do. Our labor unions, our customers, our community, our stockholders, the NAACP and similar organizations are all taking an increasingly active part in telling us how we should do our jobs.

Today, the man who is sought after is the man who can face up to these complexities in our political environment, the man who can make the necessary compromises and who can still get the job done. It is no longer enough to provide only answers which are technically perfect from the standpoint of engineering or some other profession. We must broaden our horizons to meet the problems of our increasingly complicated civilization. The good specialist must now also understand and appreciate the importance of the problems of specialists in other fields and the nature of the political machine of which he is a part.

If any individual is not able to do this, the technical knowledge he has cannot be put to its full use, and part of his education and value to the company—and value to the human race—has been wasted.

This is the challenge of our generation. We must face up to the fact that life is more complicated than it used to be. We have to be broader people—better rounded—more specialized and yet less dedicated to our special field than our grandfathers—otherwise, we cannot expect to maintain world leadership and meet the challenge which now faces our nation. ▲

Wade Hoffman, Jones & Laughlin Steel Corp., raises a question from the floor during the Off-The-Record Rolling Mill Panel Discussion.

Pictorial Roundup

AISE Spring Meeting

Sheraton Hotel
Philadelphia, Pa.
April 25, 26, 27

Members of a Rolling Mill Session talk shop before calling the meeting to order.

Mechanical Session authors and chairmen compare notes at breakfast.

Lou Moses (center) is flanked by L. M. McDowell, Bethlehem Steel Co., and R. E. Wilding, Crucible Steel Co. of America. Mr. Moses, who recently retired from Bethlehem Steel Co., was a member of the Rolling Mill Panel Discussion.

Phil Ashurst, AISE Detroit Section Secretary, and Linn Morrow, his Philadelphia counterpart, take time out for some tall talking.

S. C. Read, AISE President, chats with H. R. Wood, President of Alan Wood Steel Co., and guest speaker at the stag banquet.

C. E. Pritchard, General Superintendent of Mills, Alan Wood Steel Co.; Linn Morrow, AISE Philadelphia District Secretary and L. F. Coffin, Past President of the AISE, share a laugh with W. H. Burr, another AISE past president. Scene was the reception for Speaker's Table guests which preceded the banquet.

W. B. Lang, General Manager of Bethlehem Steel Co.,'s Steelton, Pa., plant; H. R. Knust, Assistant General Manager, Bethlehem's Sparrows Point, Md., plant; and W. E. Boger, Vice President—Operations, Alan Wood Steel Co., renew acquaintances.

Camera catches some of the 400 persons attending the banquet.

Climaxing the three-day meeting was a tour of Bethlehem Steel Co.'s Bethlehem, Pa., plant. Here, steelmen are shown en route to the Saucon Division, rolling mill facilities.

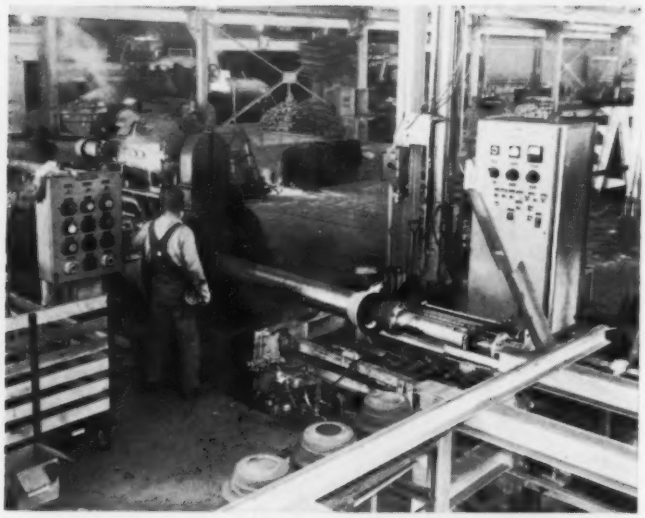


Figure 1 — A length of 20-ft cast iron pressure pipe is pulled from one of three centrifugal casting machines at the newly opened Griffin Pipe plant in Council Bluffs, Iowa. By pressing three buttons on an electronic control panel, one man can turn out a 20-ft length of pipe, extract it from a high speed centrifugal casting machine, and send it into the plant's annealing furnace.

Griffin Wheel Completes New Pipe Plant

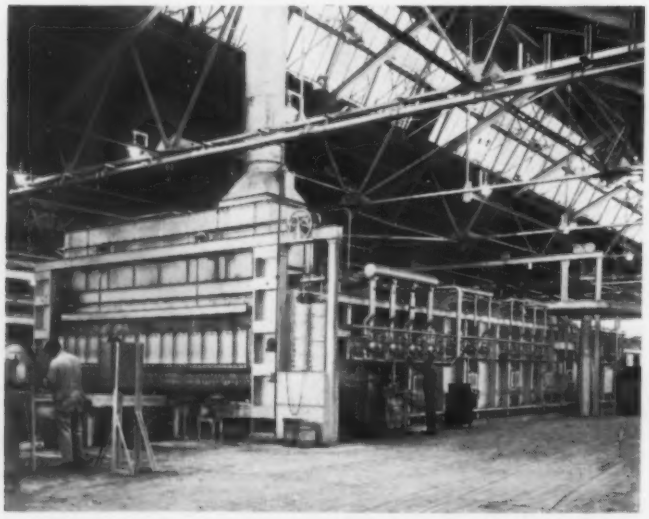
GRIFFIN Wheel Co., recently completed its cast iron pressure pipe plant in Council Bluffs, Iowa. The plant is now in full production. The opening of the plant marks the entry of Grffin into a new field for Griffin's other principal product line is freight car wheels.

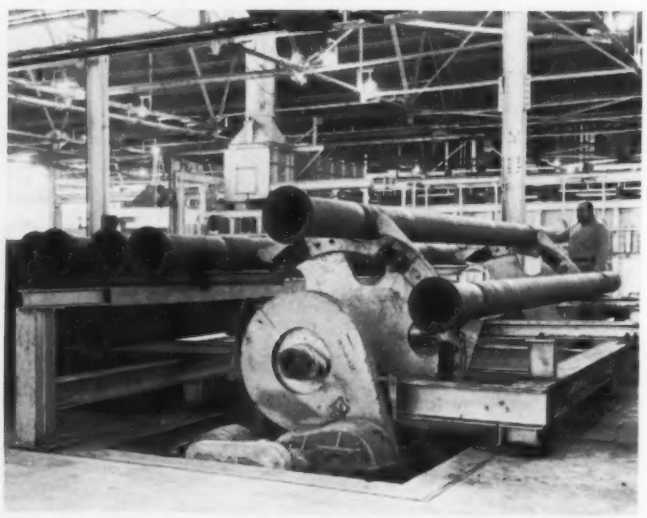
The Chicago firm formerly used the Council Bluffs plant to produce iron wheels. Conversion of the plant into a modern pipe producing facility was begun in April, 1959. Griffin pipe is cast in 20-ft lengths with diameters of 4 to 12 in. by the Delavaud process of centrifugal casting. This process uses centrifugal force to distribute molten metal within a permanent water-cooled, revolving steel mold. The new Griffin plant is the only pipe plant in the nation to produce the 20-ft length of iron pressure pipe in the 4 to 12-in. diam size range by the Delavaud process. The process also has shown promise for basic steel producers.

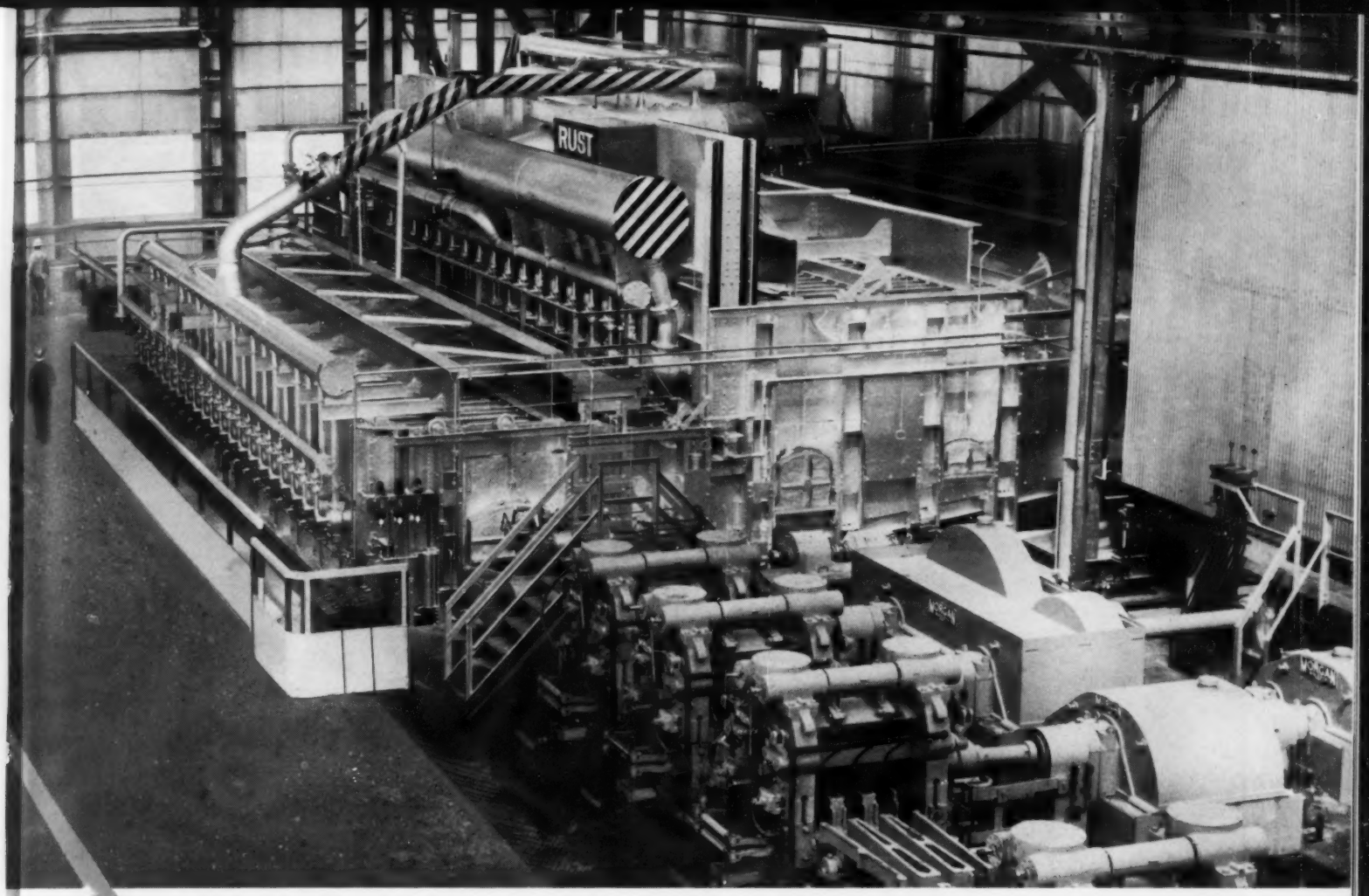
Griffin is a subsidiary of American Steel Foundries. Including the Griffin plants, ASF operates 26 plants in 15 states and Canada. ▲

Figure 2 (left) — Newly cast 20-ft lengths of iron pressure pipe automatically move into the 105-ft long annealing furnace. Pipe is annealed at 1750 F.

Figure 3 (right) — Lengths of cast iron pressure pipe are sorted according to diameter by a revolving ferris wheel, a new development in pipe plant materials handling procedure. The wheel has openings of various sizes around its rim. As it turns, pipe lengths with diameters of 4 to 12 in. move into proper slot and subsequently sort themselves onto proper chain conveyors heading toward final tests. The wheel eliminates sorting and transferring of pipe by crane.

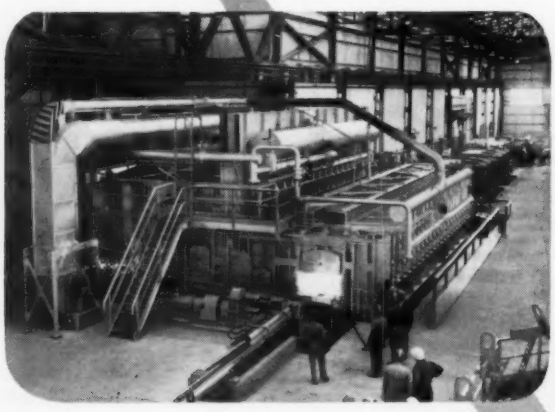






Two-Zone Continuous
Billet Reheating Furnace

for Sheffield Division, Armco Steel Corporation



• *View from peel bar side of furnace looking toward mill.*

This double-fired, two-zone furnace was designed and constructed by Rust to reheat billets in one of the fastest 10″ rod mills in the world. The mill itself was constructed by The Rust Engineering Company for Armco Steel Corp., Sheffield Division at Kansas City, Mo. The furnace is oil-fired and has a rated capacity of 112 tons per hour.

Since 1927 Rust furnaces have been recognized throughout the world for their rugged design and dependable operation.

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Progress Is Our Most Important Product

GENERAL ELECTRIC

Recent Improvements In Cleaning Blast Furnace Stoves

by HAROLD RUDICH, President, National Power Rodding Corp., Chicago, Ill.

A GROWING number of steel mill operators have found in recent years that cleaning blast furnace stoves periodically—at intervals of one, two or three years—pays substantial dividends in terms of lowered operating costs and longer stove life.

The conventional practice—i.e., cleaning the stoves after several years operation, usually at the time the furnace is shut down for major overhaul—is still widely followed. But the savings produced by such a schedule are relatively transitory, and after the cost of the job in terms of outage time and labor expense is deducted, there is not too much benefit left.

Within recent years, specialized high-powered equipment has been developed that cuts both the time and the cost of the stove-cleaning job substantially. A periodic cleaning program is now feasible from both an economic and operational standpoint.

With the new equipment and cleaning procedure, the stove is cleaned from the bottom up instead of from the top down.

The flexible, solid-spring steel rod our company used for stove cleaning, is driven by a 28-hp trailer-mounted power-rodding engine. The engine rotates the rod at speeds of up to 600 rpm, simultaneously driving it forward or backward (up or down in the flue) up to 300 fpm. This combination of movements makes the rod an extremely effective cleaning tool—far more powerful than the manual tools and small horsepower rodding rigs that have been used in the past.

Because of the centrifugal force imparted by the spinning action, the rod whips around the perimeter of the flue, in constant contact with the brickwork surface. The spinning, together with the concurrent upward and downward movement, produces an abrading action that enables the rod to dislodge the accumulated flue dust. Upon completion of the job, virtually all heat-absorbing brick surfaces are as clean as they were when originally installed. The equipment negotiates offsets easily, thanks to a small-diameter loop that forms the tip of the rod. When the loop hits an offset, it guides the rod from its previous straight-line path and quickly finds the opening in the course above. Since the cleaning rod is flexible, it snakes around offsets with ease.

Normally, when a cleaning crew enters a stove from the bottom, they are able to begin work within 48 hr after the cooling-down period begins. By comparison, when the same stove is cleaned from the top, a week or more must elapse before the temperature in the dome drops sufficiently to permit the operation to begin.

When powered equipment similar to that described above is used, a typical blast furnace stove that has 3000 to 4000 flues can be cleaned in as little as five days over-all. This is 50 to 75 per cent less time than is required by other methods.

The real significance of these time-savings, and their accompanying cost benefits, is that they make periodic stove-cleaning feasible. Because it is cleaned more often, the stove stores more heat in less time, which, in turn, increases the average hot blast temperature and reduces the regeneration period. Thus, the stove operates much closer to original design specifications, for a much longer period of its service life than when cleaned only occasionally.

The magnitude of the savings in both operating and overhead costs that can be obtained by increasing the temperature of the hot blast is indicated in a study made a few years ago by L. R. Robinson, president of the Robinson Pipe Cleaning Co., Canonsburg, Pa.

Mr. Robinson found that for every drop of 100 F in the temperature of the hot blast, there was an increase of approximately 60 lb in the coke rate per ton of production, and a drop of about 75 tons in the daily output of the furnace. The savings, in coke costs alone, produced by stove cleaning at the mills involved in the study, ranged from $885 to $3000 a day.

The benefits produced by using modern stove cleaning methods are pinpointed further by the experience of U. S. Steel at one of its major plants.

Up until the latter part of the 1930's, manual techniques were used at this plant to clean the stoves, four of which served each blast furnace. The typical unit had large checker openings, was of basketweave design, contained originally approximately 600 flues, and was capable of generating an average hot blast temperature of between 1000 and 1100 F. The gas used in these stoves received only a primary cleaning. It was passed through the conventional tower-type washers which were in common use throughout the industry during this period.

Typically, cleaning took each stove out of operation for approximately three weeks every 9 to 12 months (USS was one of the first steel companies to realize the importance of periodic stove cleaning), during which coke costs for the affected blast furnace increased substantially because of the greater heating load on the other three stoves in the group and the resultant decrease in average hot blast temperatures. A 9 to 18 man crew was engaged full time in stove-cleaning operations.

Stove cleaning then left a good deal to be desired. One serious drawback was the added coke expense. Another was the fact that after each cleaning, up to 15 per cent of the original flue capacity was lost because the crew was unable to dislodge jammed brick fragments. This condition tended to increase the concentration of heat in the dome, and eventually completed a viscious circle by burning and spalling additional checkerwork, thereby generating further brick fragments and blockages.

During the three weeks the stove was out of service, the checkers were cooled to outside temperature. Heating them up again, even gradually, imposed strains on the masonry and seriously aggravated the spalling problem.

The benefit of cleaning lasted ostensibly for 9 to 12 months. Actually, the stove's average hot blast temperature began dropping as little as six or seven months after the work was completed. In some cases, temperatures dropped to as low as 600 to 700 F in the weeks immediately preceding a given cleaning.

The old cleaning technique employed at this mill consisted essentially of dropping a weighted rope down through each flue to locate the blocked passages, then opening them with a chisel-tipped pipe. The pipe, made up of threaded sections, was fed into the flue a length at a time; a 10 to 12-lb sledge hammer then rammed it into and (hopefully) through the blockage.

At one time the plant used a high-pressure water-acid mix to clean the flues. This solvent was applied with a hose into each flue, again from the top of the stove. It was found, however, that this treatment deteriorated the masonary and aggravated spalling.

The maintenance department switched to mechanical stove-cleaning equipment early in the 1940's, and shortly after World War II began using outside contractors for the work. National Power Rodding Corp., one of the firms retained, received its first contract in 1952 and since then has cleaned stoves at this and other U. S. Steel mills a number of times.

Using specialized cleaning equipment, modern procedures and improved gas cleaning facilities, the stoves do not have to be rehabilitated as often. Those at the plant described above are now cleaned, on the average, every two years, vs every 9 to 12 months before, reducing the downtime percentage noticeably. Each cleaning takes much less time also. Typically, a multihole checker stove that has from 3000 to 4000 flues is ready to go back to work seven to eight days after being taken out of service.

Because the cleaning crews finish so quickly, the checkerwork does not become completely chilled, and thus the masonry is subjected to far less thermal stress. Spalling is much less of a problem, and average stove life tends to be greater. Also, stoves can be reheated in less time.

At least as important is the reduction in coke costs. The biggest savings are reflected by the stoves installed since World War II—these are 3600-flue units which produce average hot blast temperatures of between 1150 and 1400 F. They contain multihole, hexagonal or rectangular-shaped checkers, and are connected in groups of three to furnaces producing approximately 1500 tons of pig iron per day.

After such a stove is out of operation four or five days, at one plant the average hot blast temperature produced by the other two units feeding the same furnace drops to the point where 4000 additional pounds of coke have to be added to each charge. The cost per furnace per day is increased from $500 to as much as $5000. By getting the stove cleaned in a total of seven to eight days, instead of the three weeks or more than would be required using other methods, material costs have been cut substantially.

On the old basket-weave stoves, several of which are still operating at this plant, use of specialized cleaning equipment, together with improved gas-cleaning apparatus, has raised average hot blast temperatures approximately 100 F.

National Power Rodding Corp. guarantees to restore at least 95 per cent of the original flue capacity after a cleaning job.

Thorough refurbishing of the brickwork produces a number of important benefits. First, the danger that the top courses of checkerwork will be burned is lessened, since the heat generated in the combustion chamber can be distributed uniformly. Also, the stove maintains an optimum hot blast temperature throughout the interval between cleaning. Thorough cleaning also reduces regeneration time. This means that less gas is needed, and saves on power costs as well.

The cleaning procedure employed consists of the following basic steps: the stove, depending on its capacity, is used as a mixer for the first 24 to 72 hr it is out of regular service; then the cleanout doors at top and bottom are opened, and the brick bulkheads are removed so that the bottom can be cooled enough for the men to enter. During this latter period, a bulkhead is built in front of the chimney valve to prevent gas or high-pressure air from discharging into the bottom of the stove and endangering the cleaning crew. The stove is completely isolated by closing and locking the valves and placing the required blanks in the air and gas lines.

After the unit has been operated one to two days as a mixer, it is usually ready for starting of cleaning operations.

The trailer-mounted rig which, as indicated earlier, feeds a continuous, solid, spring-steel rod up through each flue in succession. The rod is coiled on a reel which is fluid-coupled to the drive-engine. The operator maintains close control over every movement of the rod throughout the entire cleaning operation.

This equipment is extremely flexible. We can station our trailer-mounted rig any distance from the cleanout door of a given stove when this is required by lack of immediately-adjacent open space, and run the rod through guide pipe—either on the ground or overhead—across the intervening distance. The curves and bends required for such a setup present no problems. The guide pipe, which encases the rod from the point where it leaves the machine until it enters the bottom of the flue, eliminates all types of hazards.

It takes as little as half a minute to rod one flue. Normally, we can complete a 600-flue stove in two days, and by using two rodding rigs, a 3600-flue stove can be cleaned in 4½ days. The flue dust and spalled brick, after being loosened, fall to the bottom of the stove and are easily removed.

U. S. Steel's experience with modern stove cleaning equipment is only one of many case histories that could be cited. In all of them, the savings produced by reduced outage time, longer stove life expectations, higher average hot blast temperature, and shorter regenerating time, have been substantial, compared to older techniques. Today, as a result, proper stove maintenance provides the mill operator with an extremely valuable tool for reducing over-all furnace operating costs and increasing efficiency. ▲

Are you satisfied with your ingot car maintenance costs?

These rugged 8-wheel Ingot Mold Cars haven't had one single repair job since they were bought *six years ago!* Yet they work like new. Each car is designed with an all-welded steel body that offers long life and dependable service. United States Steel has the facilities, the skilled engineers and the technical know-how to build *strong* industrial cars. You give us your specifications and requirements, and we'll design for you the finest industrial cars in the world. We would appreciate an opportunity to discuss this personally and in greater detail. To arrange a meeting write United States Steel, 525 William Penn Place, Pittsburgh 30, Pa. or any of our District Offices.

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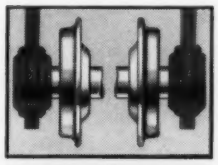
Here's how (USS) Industrial Cars are built better:

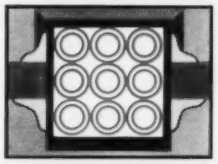
ANTI-FRICTION OUTBOARD BEARINGS:

High-capacity anti-friction bearings are located outside each of the car's eight wheels to minimize sidesway and to provide long, smooth-running performance.



SEVENTY-TWO COIL SPRINGS:

Eighteen coil springs on each side of both trucks provide a total of 72 separate springs for a shock-absorbed level ride.



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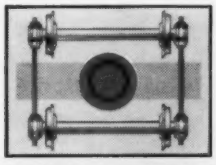
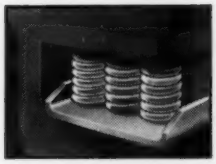
Designed for a 200-ton normal capacity load —including ingots, molds and stools —each car has a substantial built-in safety factor to withstand maximum ingot-stripping thrusts.



OVERSIZE CENTER PLATES:

"Beefed-up" center plates between the trucks and car body are 18 inches in diameter—compared with the conventional 12 inches—to reduce the load per square inch on their surfaces.



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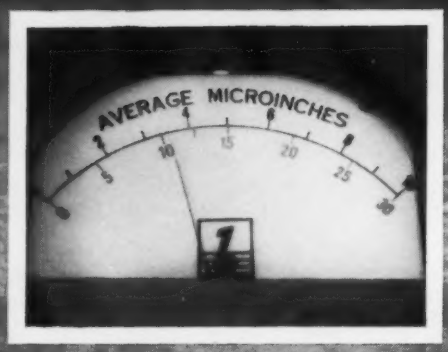
"If that nickel even quivers we have to start all over. Naturally, we don't test our gear blanks with nickels. We use a special electrical indicator, like the one in the small picture, to give us the true story on precision. But that nickel, balanced on our testing apparatus, gives you a good example of just how smooth and precise our products *have* to be."



"We depend on Cities Service for absolute precision!"

Lester E. Hoffmann, Treasurer and Vice-President
American Screw Machine Products Co., Chicago, Ill.

"The screw machine business is a highly competitive trade. We've built our business and our reputation on top quality, high-precision products . . . gear blanks that require the closest tolerances in *all* aspects. That means *we have to have* the best-quality cutting oil available. We've depended on Cities Service for nearly 25 years and they've never let us down."

"Matter of fact," says Mr. Hoffmann, "they insisted we try other brands just to prove that Cities Service was the best for us. They proved their point. We've stuck with Cities Service."

At the present time, American Screw Machine Products Co. is using Cities Service CHILLO 10 Cutting oil, and some CHILLO 22. As Mr. Hoffmann says, "The sulphur and chlorine additives prevent welding and galling action which allows for fine finishes and long tool life that maintains high-precision, top-quality work."

If you use petroleum products in your operations, why not talk with your Cities Service Lubrication Engineer? He can help you get the most from your operations by giving you the finest products, the best service available. Or if you prefer, write: Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.

CITIES SERVICE
QUALITY PETROLEUM PRODUCTS

Nippon Kokan Installs Cold Forming Line

DURING the summer of 1959, Kane & Roach, Inc., of Syracuse, N. Y., designers and builders of steel mill equipment and complete metal processing lines, shipped to Nippon Kokan, Japan's third largest steel producer, a cold roll forming line for the manufacture of highway guard rail.

The formed steel section of highway guard rail, is counted upon to do the same efficient and economical job in Japan. Due to contour of the rolls, this formed section differs slightly in design and appearance from the rail section currently being produced in this country.

The formed steel section highway guard rail has a high strength to weight ratio, and the heavy gage steel has a natural shock absorbing quality. It is made in the United States by the "mile." Its low cost easy maintenance also makes it much in demand because damaged sections along the highway can be replaced very rapidly.

The guard rail forming line, engineered and built for Nippon Kokan will also be tooled up for several other shapes. A demand was found in Japan for the construction and building products that are normally roll formed in this country. For example, a "C" shaped structural and a "trench sheet" are the next items the Japanese propose to roll form on the same cold forming line.

The entire processing line consists of a payoff cradle, coil reversing leveler, 200-ton automatic "flying" piercing press, a 30-ft gaging table for the hole piercing operation, a cold roll forming mill, a 150-ton "flying" cutoff and a 30-ft long power-driven runout table.

Fully automatic in operation, the entire line is designed to operate at 150 fpm. The cold forming mill of the "universal type" has all of its rollshafts driven through universal joint shafts from a double output shaft pinion stand, which contains the necessary worm gear reduction drive. All of the pinion stands are, of course, driven through the worm shafts which are coupled together.

The forming milldrive is a 150-hp motor driving a four-speed herringbone gear type transmission, and using a Wichita Falls 21 in. disc type air clutch to connect with the mill proper.

In operation, the coiled steel is fed from the payoff cradle through a "decoiling" leveler, and then through the flying piercing die in the pre-punching press. The strip then travels along a 30-ft hole gaging table equipped with a trigger mechanism that automatically picks up the previously punched group of holes and actuates the piercing press; then into the cold forming mill proper.

After exiting from the forming mill, the formed section enters a flying cutoff die in the cutoff press. As the section travels along the driven roller type runout table, it contacts a length trigger which is set for the proper overall length of the finished piece—this length is, of course, in direct relation to the groups of holes already prepunched on the entry end of the process line. Shorter sections and sections that do

Figure 1 — Payoff cradle starts flat stock along the line. The coiled steel is fed through a "decoiling" leveler, and then through a flying piercing die in the prepunching press. Next is the 30-ft table. The driven table accelerates the cut piece away in order to give the trigger mechanism a chance to reset for the next cycle.

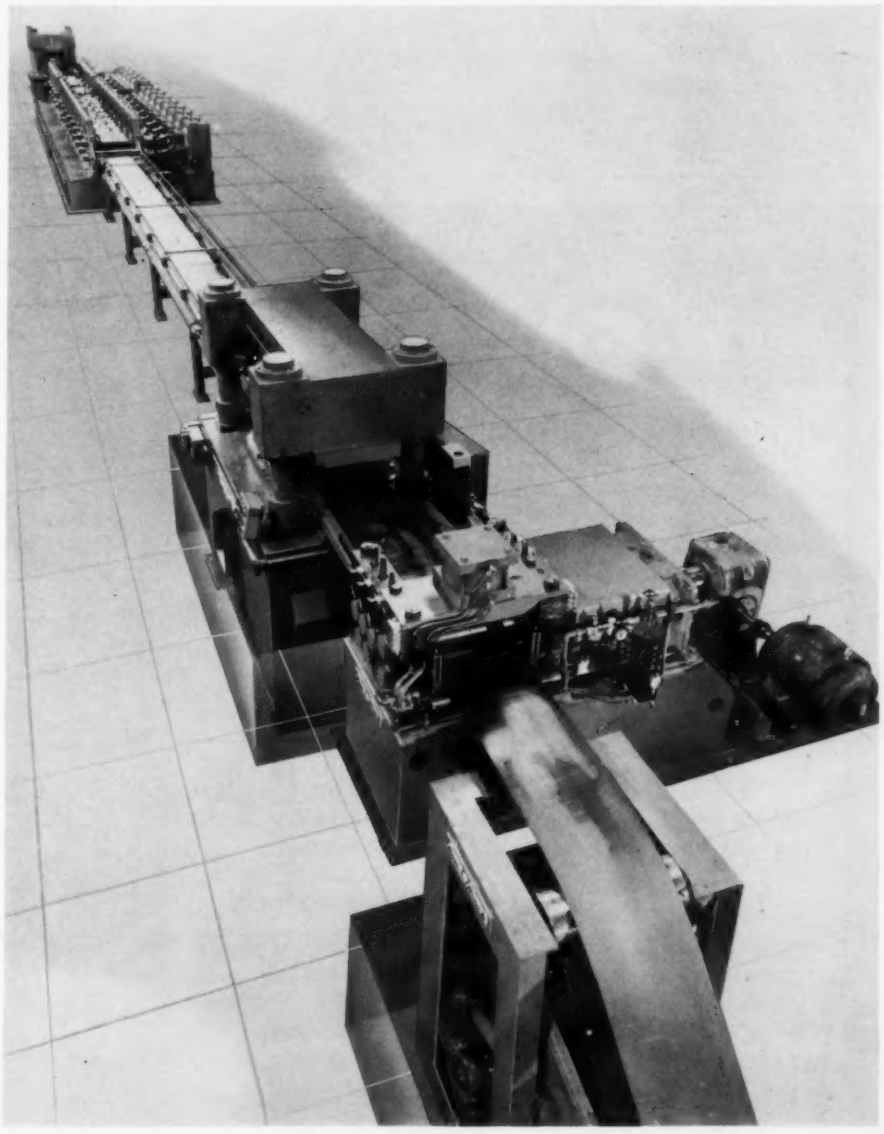


Figure 2 — The 200-ton flying automatic piercing press has a 30-ft hole gaging table equipped with a trigger mechanism that automatically picks up the previously punched group of holes and actuates the piercing press.

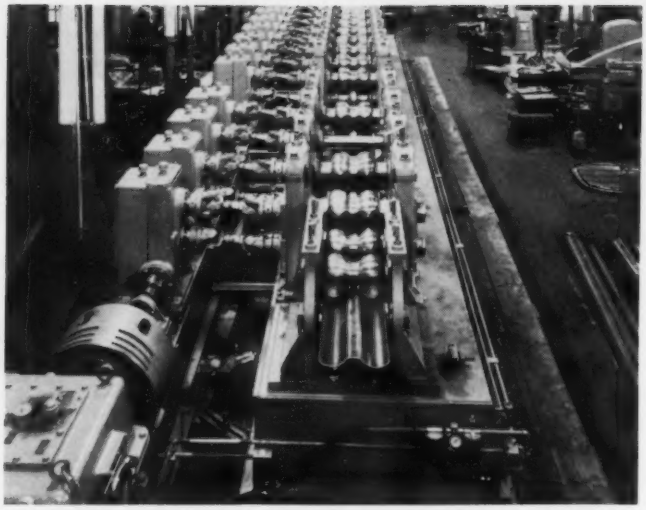


Figure 3 — The cold roll forming mill is of the "universal type." All rollshafts are driven through universal joints from a double output shaft pinion stand, which contains the worm gear reduction drive.

not incorporate the hole punching operation are cut to length using a positive gage type of trigger mechanism.

After the section is cut to length, the driven table accelerates the cut piece away from the oncoming section in order to give the trigger mechanism a chance to reset for the next cycle.

Both of the presses in this production line are equipped with air-operated accelerators which accelerate the dies from a standstill position to the speed of the strip in only a few in. of actual travel. These flying dies are equipped with bronze lined shoes which ride on the hardened and ground rails installed in the press bed and ram.

During the operating cycle of the press, the die is moved along rails by the columnar strength of the section itself. When the press ram stops at the top of the stroke, the open die is returned to its starting point to await the signal for the next cycle.

The Kane & Roach line, which is approximately 168 ft in over-all length, has production speeds of 40 to 150 fpm, depending upon the desired length of the sections being cut off. ▲

EXECUTIVE REPORT #15

THIS WHEEL PLAYS 9 ROLES

To Cut Costs for Steel Producers

In the production or fabrication of steel, the Wheelabrator airless abrasive blast wheel is playing 9 or more starring roles. It excels as a cost- and time-saver in descaling strip, sheets, plate, bar stock, skelp, structural shapes, wire rod, slabs and billets, at mill roll etching, ingot mold conditioning, and other specialized applications.

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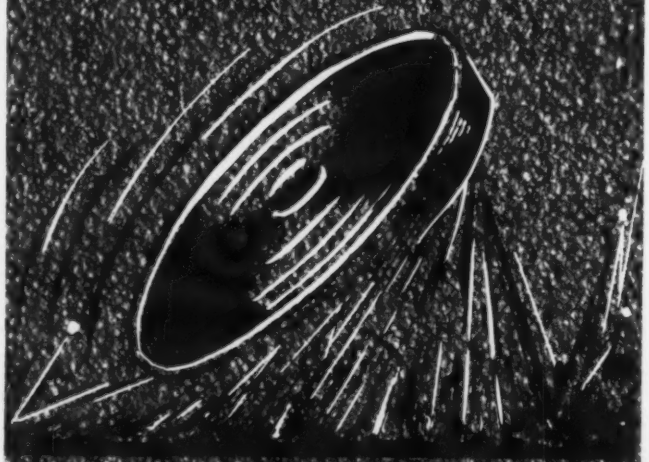
Wide use throughout the steel industry has proved the Wheelabrator process. For engineering consultation on your problem, write Wheelabrator Corp., 396 S. Byrkit St., Mishawaka, Ind. In Canada, P. O. Box 490, Scarborough, Ont.



WHEELABRATOR
AIRLESS BLAST EQUIPMENT

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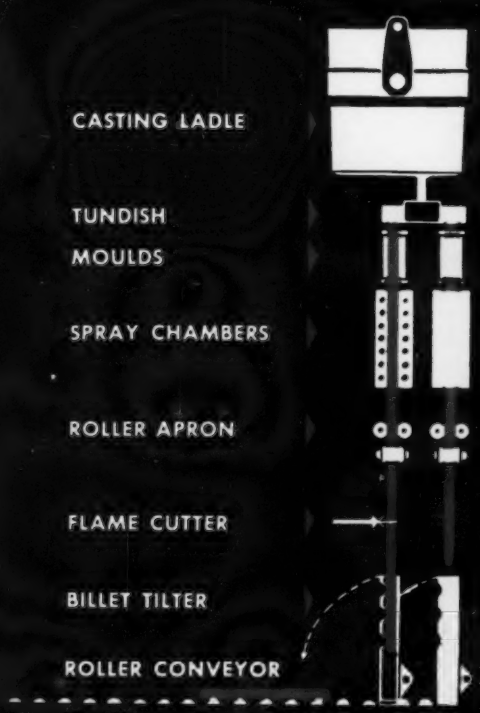
CONTINUOUS STEEL-CASTING PLANTS



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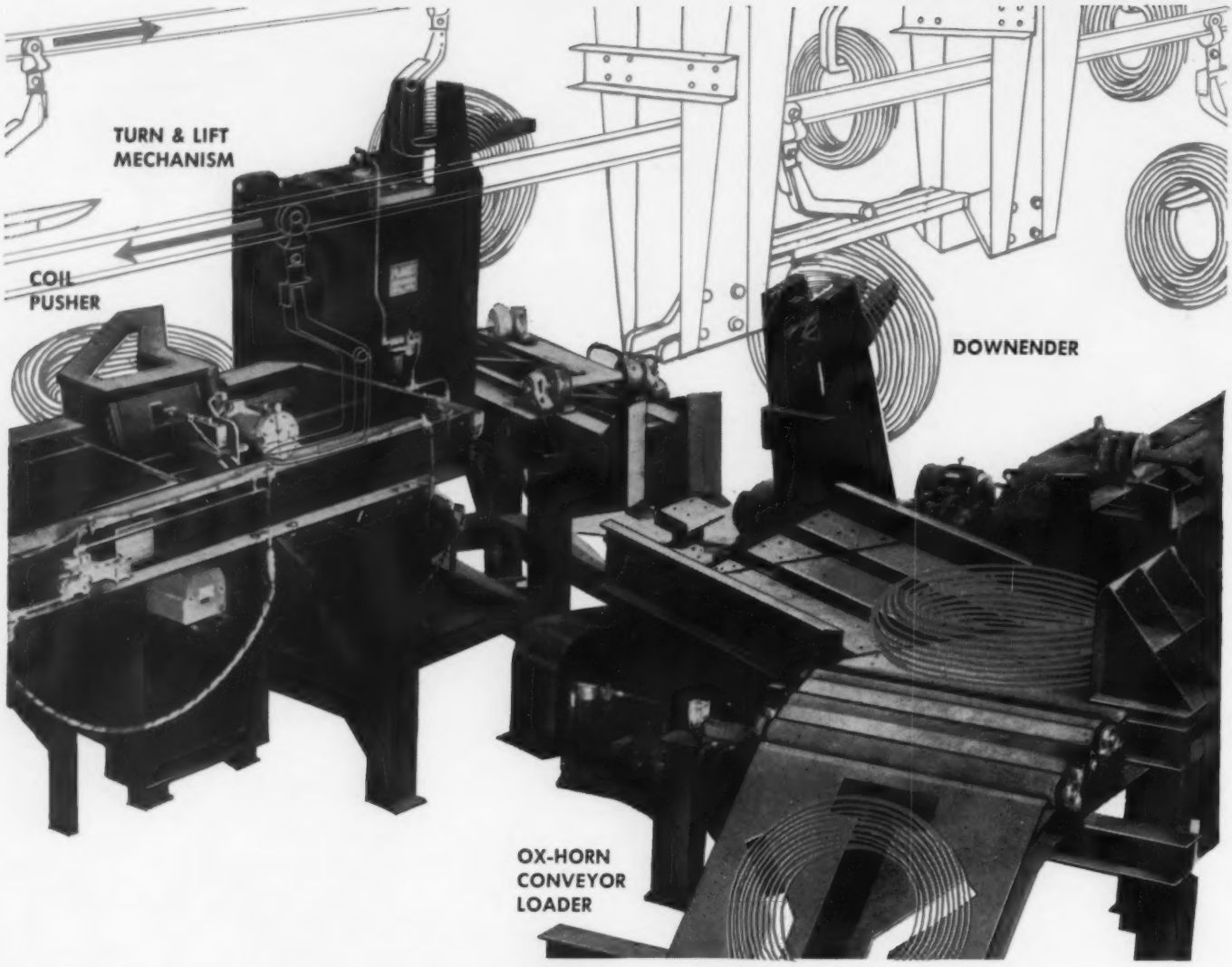


another example of Planet Versatility...

COIL HANDLING SYSTEM LOADS AND UNLOADS EXISTING CONVEYORS AUTOMATICALLY

This automatic coil handling system is an example of how *Planet Versatility* helped one of America's largest steel mills modernize its 10-inch bar mill to handle larger, 2000-pound bar coils . . . and save money by designing the coil handling equipment to load and unload *existing* conveyors.

A red-hot, 2000-pound bar coil is transferred from an existing drag-chain conveyor to the automatic trolley conveyor loader by a single arm coil pusher. The coil pusher deposits the coil on a drop table which, when lowered, leaves the coil hanging on one arm of a turn and lift mechanism. As this machine revolves 180 degrees it lifts the coil into position to be engaged by a trolley conveyor hook and, at the same time, lowers its other arm to receive the next coil. After cooling on the existing trolley conveyor, a downender removes the coil and sets it on a slider bed on which it is indexed into a banding position. The coil is then transferred onto an existing ox-horn conveyor. *The entire system operates on a 15-second cycle and is completely automatic.*

This automatic coil handling system is more evidence of Planet's versatility . . . its ability to engineer, manufacture, and erect automated systems which solve the most perplexing production, materials handling, and automation problems. Planet has automated production lines, built bulk and unit materials handling systems, designed and erected complete plants . . . and Planet systems are found in the plants of leading manufacturers in almost every industrial classification.

Write or phone to have a Planet engineer demonstration how "PV" can help you . . . you'll find *it pays to plan with Planet.*

912

Bethlehem To Expand Sparrows Point To 9,000,000 Tons

DETAILS of Bethlehem Steel Co.'s program to expand the rated ingot capacity of its Sparrows Point, Md., plant to 9,000,000 tons annually were disclosed recently. A planned ten per cent increase will add 800,000 tons to a plant already rated the nation's largest at 8,200,000 tons.

Construction will get underway on all phases in 1960 with some being scheduled for completion by December. Others will not be completed until 1961 or later.

The following are the objectives of the new expansion program:

1. Increased efficiency in steelmaking operations.
2. Continued improvement in the quality of products.
3. Extended range of weight and size of some products.
4. Improved materials handling, including shipping.

Most of the increased tonnage will be provided by adapting the plant's new No. 4 open hearth shop for the use of oxygen. This shop contains seven furnaces rated at 375 tons each.

The over-all program, however, entails the nine following projects: rebuilding a coke oven battery, increasing iron ore sintering capacity, addition of new soaking pits, modernizing the 60-in. plate mill, modernizing the flange mill, modernizing the 56-in. hot strip mill, adding a new continuous annealing line for tinplate, adding new capacity in the wire drawing and bethanizing departments and installing a new fuel oil storage and distribution system.

Although some of the projects are still in the engineering stage, others are in progress.

At the present time, work on rebuilding the No. 2 coke oven battery is well underway. It will be the third such battery to stand on the same site. Earlier ones were constructed in 1913 and 1929.

The capacity of the sintering plant will be increased.

Three new soaking pits will be added to heat the additional steel produced by the oxygen-equipped furnaces. At present, two of the seven furnaces are using oxygen lances. To supply these as well as the other five in No. 4 shop, an oxygen plant with a daily capacity of 350 tons will be installed. In addition, this plant will contain facilities for supplying nitrogen to annealing furnaces in some of the finishing mills.

Modernization of the 60-in. universal plate mill will result in improved efficiency and product quality. The unit itself will be rebuilt, a new slab preparation yard constructed, a new hot leveller added, and numerous changes made in the mill roller lines.

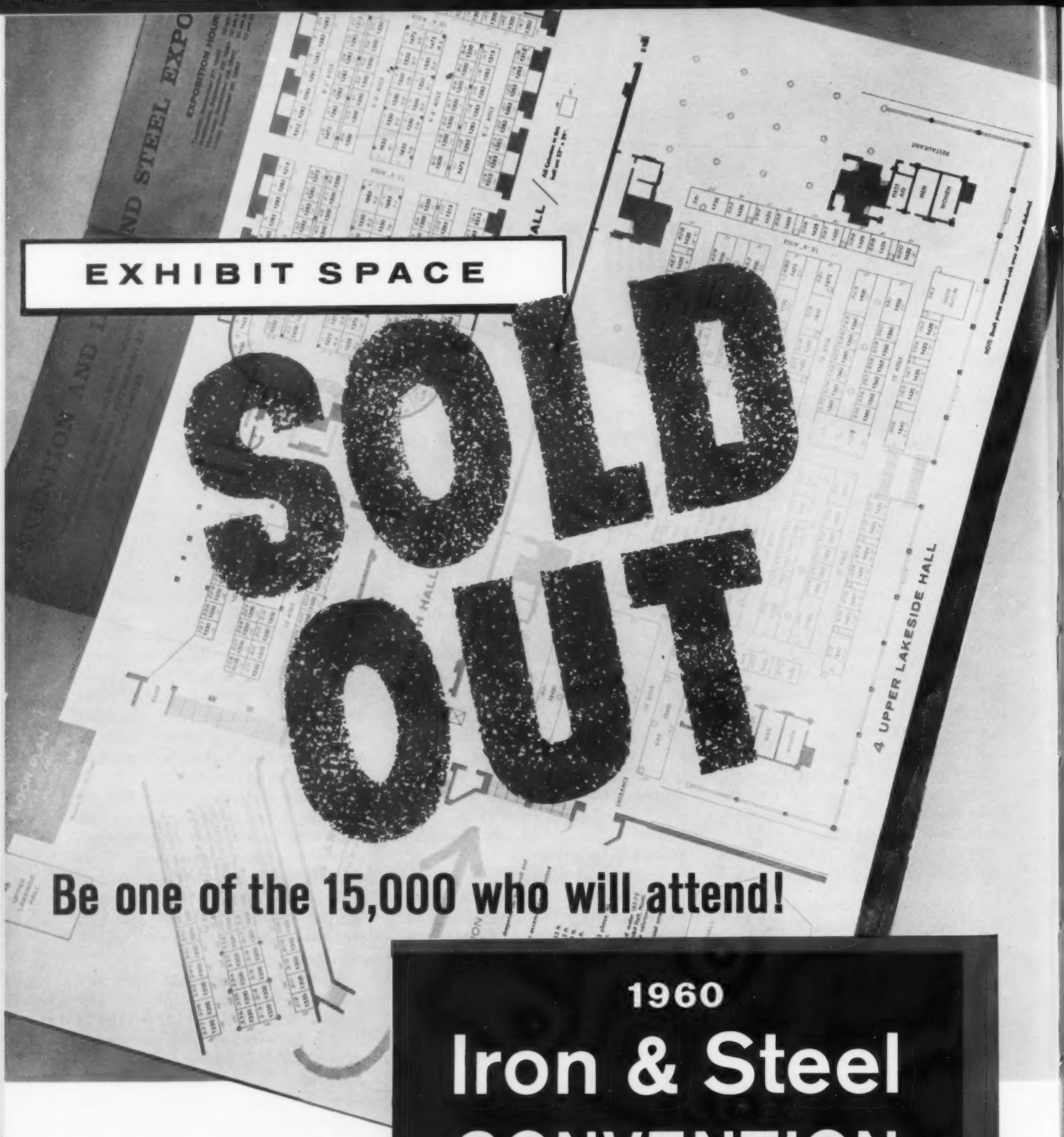
Modernization of the flange mill, which makes flanged and dished heads for tanks and other industrial uses, will enable the plant to provide a greater range of products of improved quality.

Changes in the 56-in. hot strip mill will enable it to roll coils of sheet steel twice as long as those now produced and to increase output by almost a half-million tons per year. A new roughing stand will be added and other roughing stands replaced. Three new furnaces and three new coilers will replace similar existing facilities.

Because of technological changes in the can-making industry, an increasing quantity of tinplate requires "continuous annealing." Consequently, a new high-speed line will be installed to process steel strip at speeds up to 2000 fpm and increase existing capacity by 50 per cent.

New wire drawing machines and auxiliaries at the wire mill will provide an additional 3000 tons of light gage wire capacity per month as well as provide for heavier wire coils now in demand by various manufacturing customers. New high-speed electro-galvanizing units will be added to provide for increased production of bethanized wire.

Additional fuel oil storage and distribution facilities will enable large tankers, many of which have been built in Bethlehem's adjacent Sparrows Point Shipyard, to deliver full cargoes at maximum pumping rates. The increase in storage capacity will about equal the capacity of an enlarged T-2 tanker, or approximately 7,000,000 gal. ▲



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1960

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Four full days of technical sessions will be held concurrently with AISE's *largest* Exposition. Your associates and competitors will be there to learn of trend-setting developments in all phases of engineering, production and maintenance.

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Figure 1 — A set of two thermotomic sideboards are placed lengthwise in the heads of big end down slab molds. They ignite on contact with the molten metal as it is poured from the ladle. With the additional exothermic heat which sideboards supply, the ingot cools more uniformly. The yields of ingots thus processed show a six per cent or more increase in finished product.

Exothermic Sideboards Increase Ingot Yield

ALLEGHENY Ludlum Steel Corp. recently disclosed a new pouring procedure whose initial results show up to a six per cent increase from ingot to shipping weight in alloy and stainless tests over conventional hot topping methods.

Full heats up to 85 tons have shown a consistent increase in steel produced with the new procedure which eliminates hot tops and substitutes two easily handled exothermic sideboards specially developed by Pittsburgh Metals Purifying Co. for Allegheny Ludlum. The sideboards are made to fit along the two opposite sides in the heads of big end down slab molds.

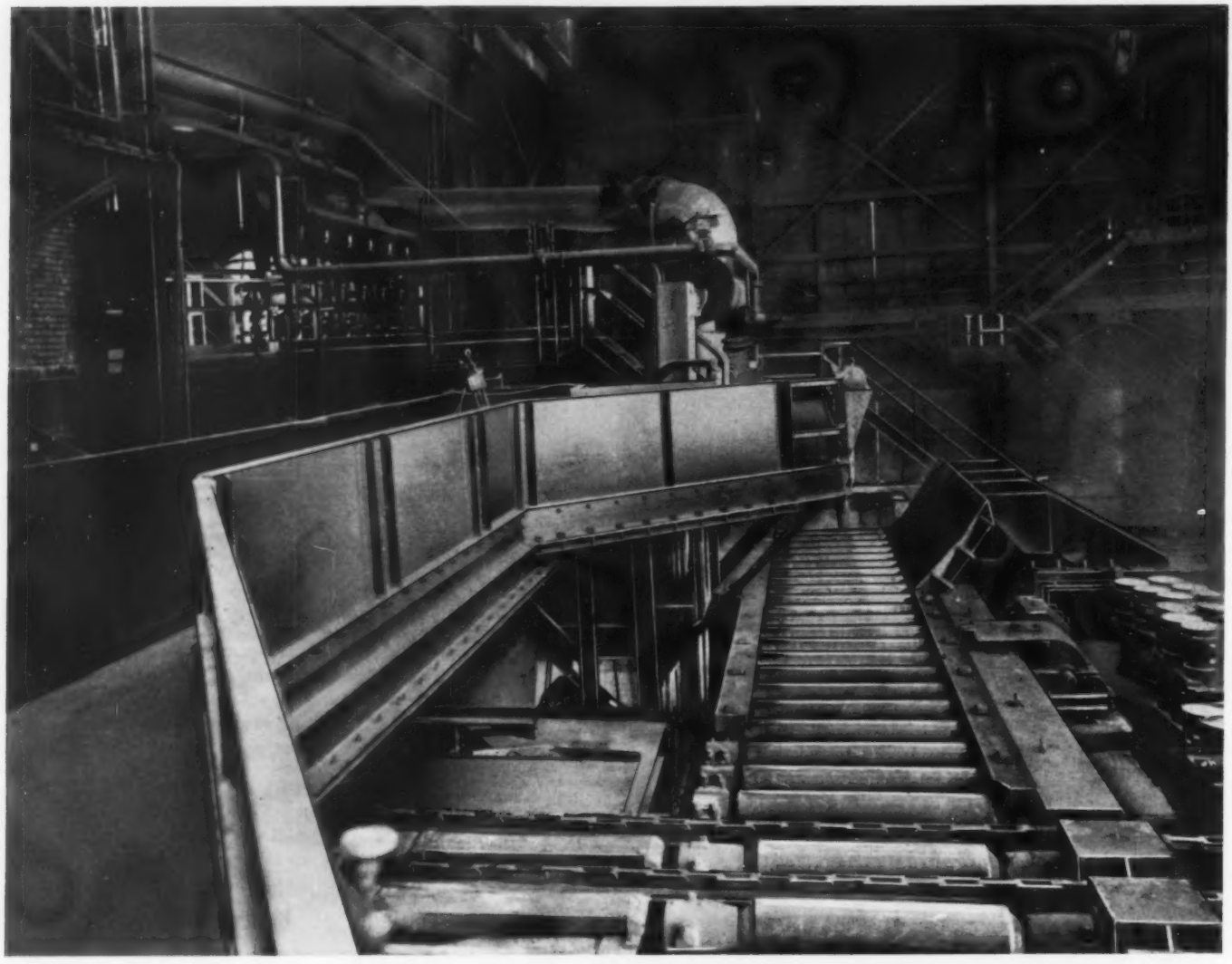
Besides yielding more slab steel per ingot, the innovation simplifies handling, reduces track time, increases mold life and uses big end down molds which are faster and easier to strip than big end ups, currently used by most alloy and stainless producers.

Despite the widely held opinion that such procedure would not work theoretically, results to date indicate that theory is not practice. Metallurgical quality of standard products made by using the new exothermics is equal to that of conventional procedure. Ultrasonic tests show the steel to be sound in every respect.

While the big pay-off is in more steel per ingot, several other advantages are gained in the new method. Crane time in hot topping is replaced by one man handling of the exothermic sideboards. The care that must be exercised in placing the hot top in position to prevent leaking and other trouble is countered by the ease of positioning the two sideboards. Debris often imbedded in the ingot requires a clean up job in the soaking pit, which is eliminated by the use of sideboards. Further, sideboards take up less storage space than hot tops as ten of the sideboards can be stored in the space required by one hot top. Also, mold inventories can be reduced by virtue of using the big end down mold instead of carrying on inventory both big end up and big end down in the same size.

As to actual material cost, brick hot tops cost approximately 50¢ a ton less than the exothermic sideboards but it is anticipated that with greater use of the sideboards, their cost will tend to more nearly equal that of hot tops.

From all indications this could be a major productivity development for the stainless steel industry. ▲



OVER 60 YEARS OF ENGINEERING

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BUILT THIS FURNACE DELIVERY TABLE

17 feet x 80 inches with heavy sloping bumpers, this furnace delivery table can handle 30,000 pounds of hot slabs discharged from the furnace. Designed and engineered by Treadwell for an Eastern Steel Company. You can *always* count on Treadwell for durable, dependable machinery.

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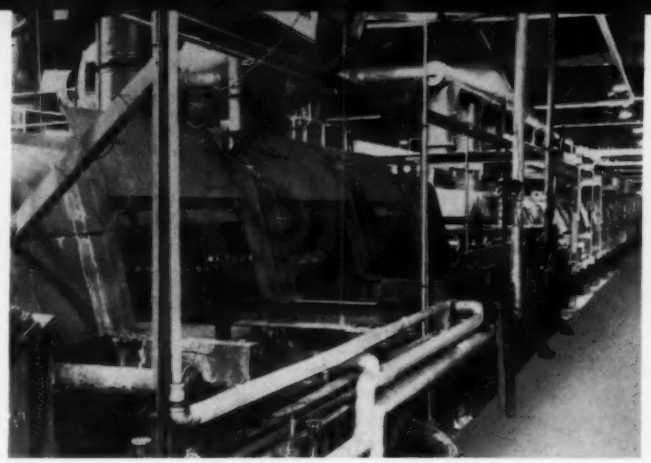


Figure 1 — This electrolytic galvanizing line is now in production at Youngstown's Struthers plant.

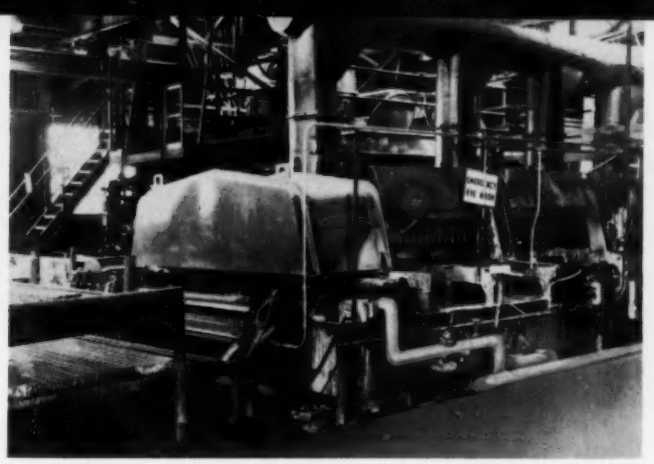


Figure 2 — Tubing is carried into the line, one piece at a time, on an endless chain.

Youngstown's Conduit Line Cuts Finishing Time

AN important advance in the steel industry's increasing use of automated equipment has been achieved by Youngstown Sheet and Tube Co. Long one of the nation's leading producers of conduit, the company has recently increased its conduit production capacity more than 80 per cent by the installation of a fully automatic conduit processing machine.

The new processing line eliminates much handling time, reduces finishing time, bundles tubing automatically and paints conduit both inside and out. Youngstown is the only manufacturer of conduit to paint the outside of electrolytically plated tubing.

The conduit line, designed and manufactured by Hanson-Van Winkle-Munning Co., Matawan, N. J., is 325 ft long and cuts production time from 5 hr to less than 1 hr. As an added bonus, the conduit emerges from the machine with a lustrous galvanized finish instead of the dull finish previously produced.

The installation has a maximum production capacity of more than 1200 10 ft units of ½-in. EMT (electro metallic tubing) per hr. As the size of the tubing increases, finishing time is increased proportionately. While 20 units a minute are processed when the tubing diameter is ½-in. for 2-in. tubing, this rate falls to ten pieces a minute.

Loading end—Tubing manufactured at Struthers Works is transported by overhead crane (to speed loading operation) from the storage room and placed on a loading platform. Here the tubing is picked up, one at a time, by an endless chain and carried to the finishing line.

Conduit line layout—The equipment consists of a series of cleaning, pickling and electrogalvanizing tanks arranged in a straight line. This arrangement enables each piece to move to the next operation or bath in a minimum of time. Forty-five minutes elapse from the moment the conduit is picked up until it emerges as a finished product from the end of the line. The conduit travels at 7 fpm through the machine.

During the forty-five minute cycle the tubing goes through the following cycles:

1. Alkali soak cleaner.
2. Hot water rinse.
3. Electrolytic alkali cleaner.
4. Hot and cold water rinses.
5. Acid cleaner.
6. Two more cold water rinse baths.
7. Two electrolytic plating baths.
8. Two more water rinses.
9. Brightening bath.
10. Cold and hot water rinses.
11. Gas drying.

In the dryer, conduit is dried at a temperature of 300 F.

Once out of the dryer, the tubing is held for a few moments in a small supply hopper. A conveyor picks five pieces of tubing at a time, out of the supply hopper. An hydraulic lift mechanism then raises the pipe from the conveyor to the spray position.

A painting machine carries five

Figure 3 — Bright galvanized tubing comes out of the dryer, rolls across the inspection table and is bundled automatically.

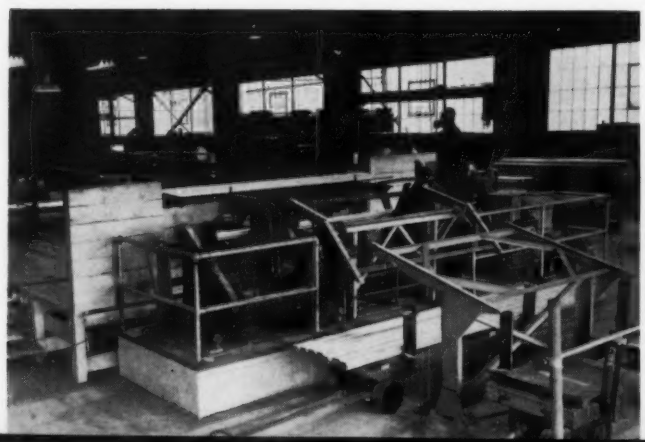
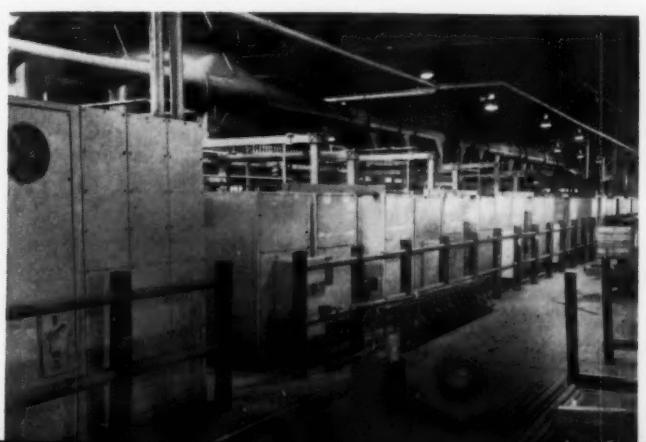


Figure 4 — Nine remote controlled germanium rectifiers supply power to the conduit line.



paint-filled pressurized spray nozzles inside the tubing. As the nozzles are withdrawn, the inside of the tubing is sprayed with paint. A few feet farther on, the outside surfaces of these five pieces of conduit are sprayed with quick-setting lacquer. After painting, the tubing is returned to the conveyor which discharges five lengths of painted conduit at a time.

The five pieces of conduit are picked up by another endless chain and carried into a gas dryer with a temperature of 375 F. From there it goes into a 30-ft cooling tower where forced air brings the tubing down to approximately 120 F.

Rolling out on the inspection table, the pieces are checked by skilled inspectors who look over both the inside and outside finishes. Passed by the inspectors, they are automatically stamped with the company's label and rolled onto the bundling table.

An operator, checking the number of pieces, presses a button and the automatic bundler wraps pressure sensitive tape around each end of the bundle. Bundles are lifted automatically out of the bundler and dropped into a pocket to be picked up later by an overhead crane and taken to the warehouse.

Liquid volume of all cleaner, pickle, zinc and rinse tanks total approximately 32,000 gal. Hanson-Van Winkle-Munning Co. and E. I. DuPont de Nemours, Inc., supply all chemical components.

Solution tanks are made of steel or rubber lined steel. Steel or lead heating coils mounted in various tanks are capable of heating solutions up to 200 F. Exhaust hoods remove fumes and float-operated valves are provided to maintain the proper solution level.

Power supply—The source of power to operate this unit comes from nine remote controlled germanium rectifiers ranging from 5000 amp, 12 volts to 10,000 amp, 9 volts. Rectifiers are designed and manufactured by H-VW-M.

Twenty-one motors totally enclosed, ranging from 1 to 60 hp are furnished for driving, pumping and exhausting the equipment.

Safety features—Exposed moving parts, such as couplings, V-belt drives, chain drives, etc., are protected by suitable guards and covers to assure safe working conditions.

All tubing produced at the plant meets the rigid standards and specifications of Underwriter's Laboratories. ▲

British Plant Orders Two Large Rotating Oxygen Converters

THE Stora-Kaldo oxygen steelmaking process, which has attracted considerable interest throughout the steel industry, will be introduced into Great Britain late next year. Two 100-gross ton Stora-Kaldo converters have been ordered by the Consett Iron Co. Ltd., a northern England firm. Production is scheduled for the end of 1961.

Developed by Stora Kopparbergs Bergslags Aktiebolog, of Domnarvet, Sweden, and marketed and constructed in the United States and Canada by Dravo Corp., the Stora-Kaldo process has gained attention for its high operating efficiency and low installation cost. It features the use of an inclined, variable-speed rotating furnace for reduction of pig iron to steel.

A 30-ton converter has been in operation at Stora Kopparbergs' Domnarvet works for several years. Two 100-gross ton vessels will go into operation at Thionville, France, May 1 and two more 100-gross ton furnaces will begin producing steel at Oxelosund, Sweden, in late 1960.

Working with the Swedish firm, Dravo engineers have developed a number of different size vessels for use in this country. These range in capacity from 25 tons to 200 tons. A 100-ton vessel, similar to those ordered by Consett Iron, is 12 ft-9 in. inside diam. and 21 ft-8 in. inside length.

Developed primarily for production of steel from Sweden's high phosphorus ore, the Stora-Kaldo process will be used with medium phosphorus ore in England. It also can produce top quality steel in a broad range of specifications from low phosphorus ore, the type generally used by the steel industry in Canada and the U. S.

Ingot yields in excess of 91 per cent can be expected from average United States pig iron with scrap additions. Blowing rates exceed three tons a minute.

Operating experience has indicated that a Stora-Kaldo installation in this country or Canada would cost 50 to 65 per cent less than a new open hearth shop with similar capacity and auxiliaries.

Although the Stora-Kaldo furnace resembles a conventional bessemer converter in shape, it is rotated on its longitudinal axis at variable speeds up to 30 rpm at an inclined angle of 17 degrees from the horizontal. Oxygen at a pressure of 40 to 50 psi is injected into the vessel through a water-cooled lance, producing a quiet reaction and consequent reduction of the volume of solids in exhaust gases.

The open-hearth type of reaction inherent with Stora-Kaldo, combined with the furnace's rotational characteristic, permits selectivity in the elimination of metalloids and produces low phosphorus, low nitrogen and low sulphur steel at an easy-to-control tapping temperature.

Controlled rotation of the vessel and its consequent influence on slag composition produces a slag with low iron content, further contributing to high yield.

The ease in stopping carbon elimination in the refining process at a predetermined point facilitates carbon control and eliminates the necessity for recarburization. Since virtually all carbon monoxide is converted to carbon dioxide within the furnace, gas volume and the cost of gas cleaning both are at a minimum. This also permits melting of large quantities of iron ore, sinter or scrap, resulting in a high steel tonnage per ton of molten pig iron charged. ▲

BLAST FURNACE GAS WASHING

Chemico P-A Venturi washers selected for 36 installations at 20 separate plants...

In furnaces from coast to coast, the Chemico P-A Venturi washer is proving the single most economical and effective method of cleaning blast furnace gases. Prior to the introduction of the Venturi blast furnace washer, the dust content of the gas from conventional primary washers ranged from 0.15 to 0.35 grains/CF. The Venturi washer can achieve results as low as 0.005 grains/CF.

Low initial cost, inexpensive installation and virtually no maintenance are the more obvious economic advantages of Venturi blast furnace washers. In addition, however, Chemico Venturi washers require very little water—one-third as much as conventional washers—and permit complete recycle.

They are rugged units which have proved their reliability and long life in actual working furnaces. Also important is their ability to handle wide fluctuations in gas volume without sacrificing cleaning efficiency. With 36 units now in operation or on order, you can be certain of proven performance with a Chemico P-A Venturi washer.

If you are considering the installation of gas cleaning equipment in a blast furnace, a Chemico representative would be pleased to show you the kind of top-performance job you can expect from a Venturi washer. And remember, Chemico handles the complete job... PLANNING, DESIGN, ENGINEERING, ERECTION and START-UP.

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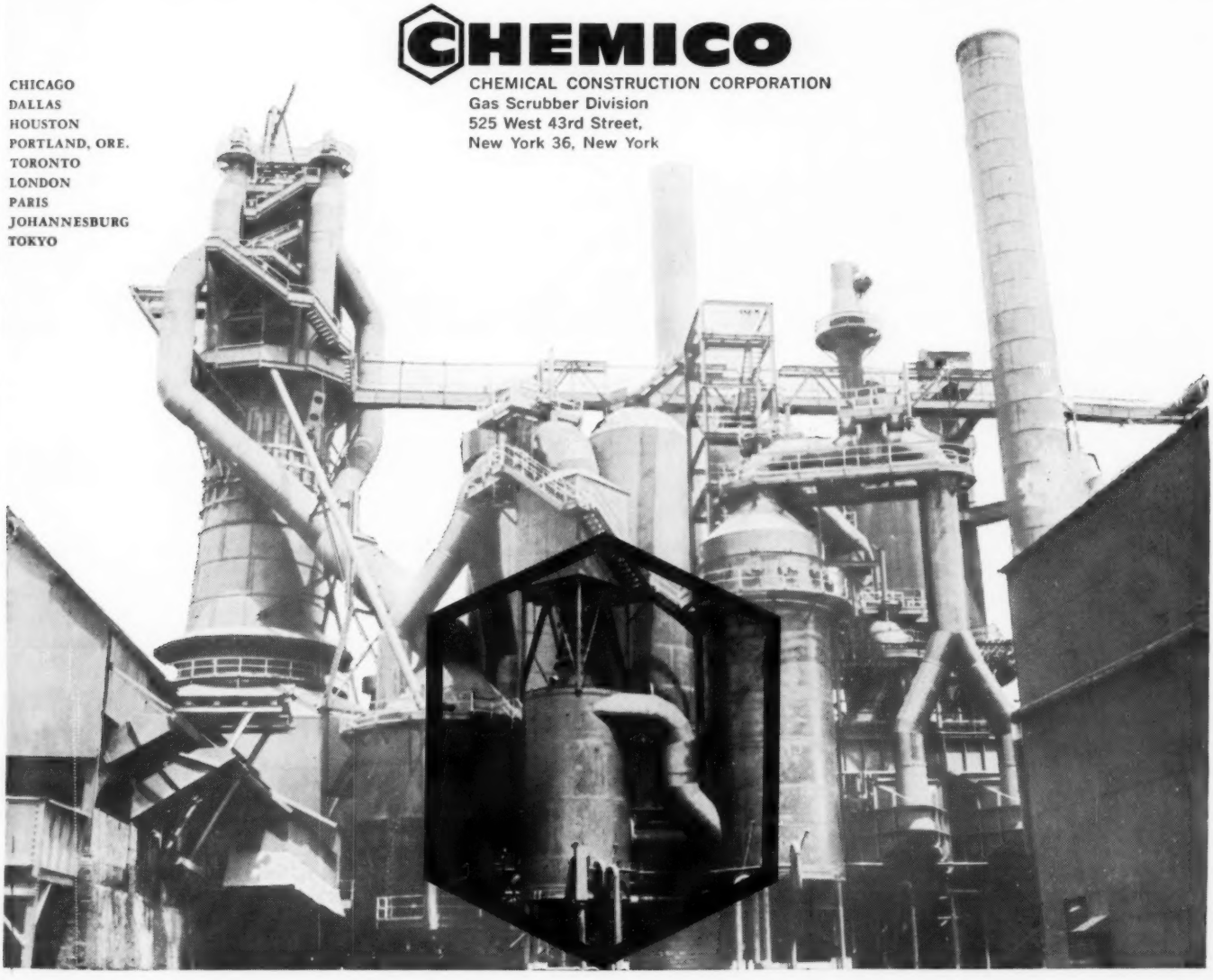


FOR QUALITY... PRODUCTIVITY ... PROFIT

INTEGRATED AUTOMATION BY GENERAL ELECTRIC

G. R. BROWN, Manager of General Electric's Metal Rolling and Processing Sales, talks about new automation capabilities at General Electric.

Integrated Automation

"General Electric is ready now to assist you with the ultimate in automation . . . automation of your entire plant."

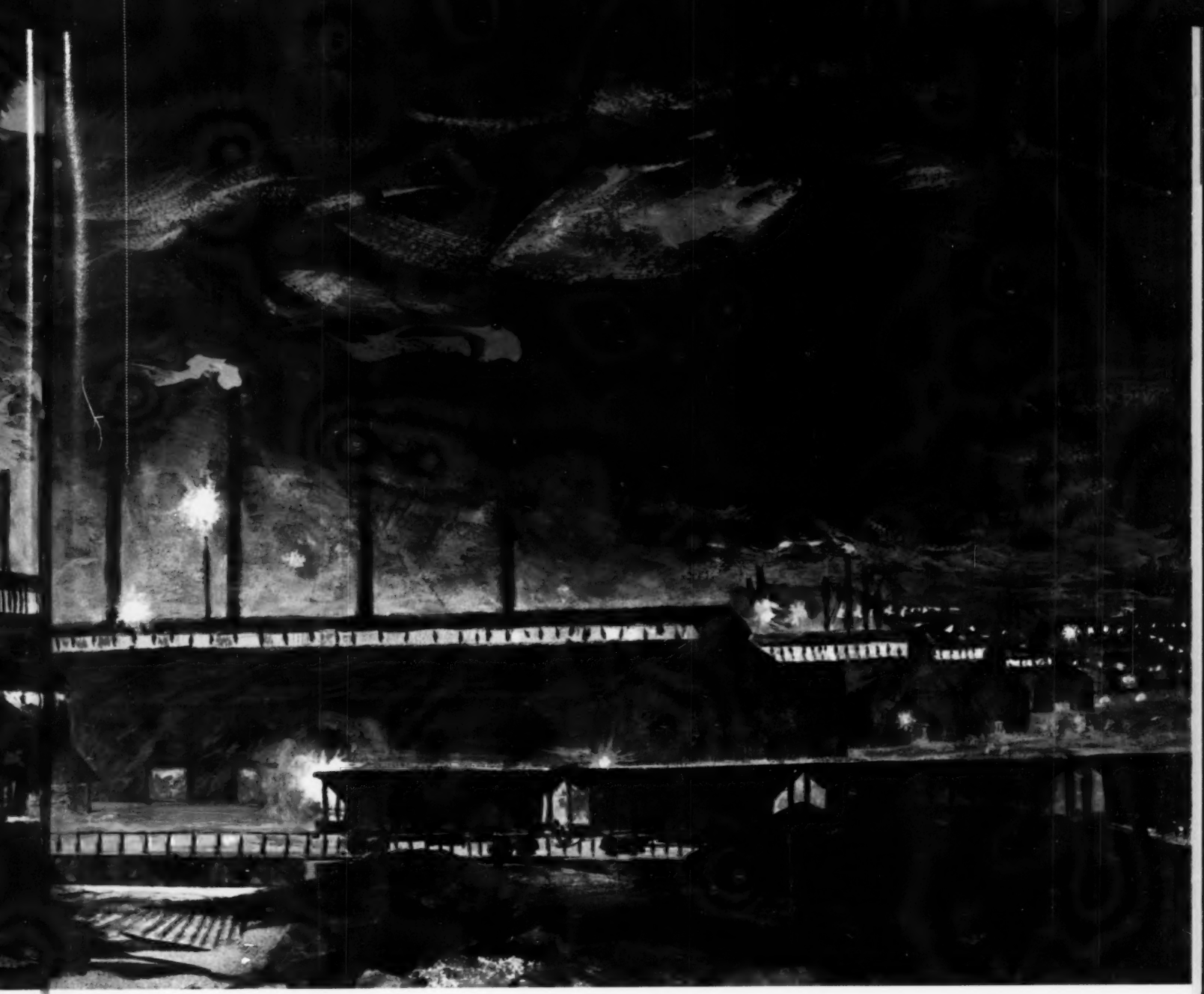
To date, General Electric has concentrated on the complex problems of automating your individual processes. Now, with actual installations completed, individual-process automation has become a reality. General Electric has now taken the next logical step in sound automation planning.

With newly developed products and system technology, General Electric engineers can now link your "islands of automation" to provide complete automation of an entire production area.

With this major phase of your automation program complete, it then becomes possible to link automated production areas by means of a master computer-control system, thus providing completely integrated automation of the entire plant.

Based on a step-by-step modernization approach, General Electric's plan provides flexibility for technological and economic developments in your company. At the same time, it enables you to begin now, taking advantage of the many benefits of automation.

For example, the first step in integrated automation has already been taken by many metal producers. New rolling mills automated by General Electric are automatically keeping strip "on gage" to minimize scrap and boost yield. Primary rolling costs are being reduced through application of G-E programming and



n means effective control of your entire plant

computer systems. G-E automated systems will eliminate charging errors in many blast furnace operations, increasing furnace profits. In many mill operations, G-E automated systems are making available, immediately, critical data in the most usable form to permit wise and timely management decisions resulting in improved and more consistent product quality, reduced operating costs and optimum utilization of the mill.

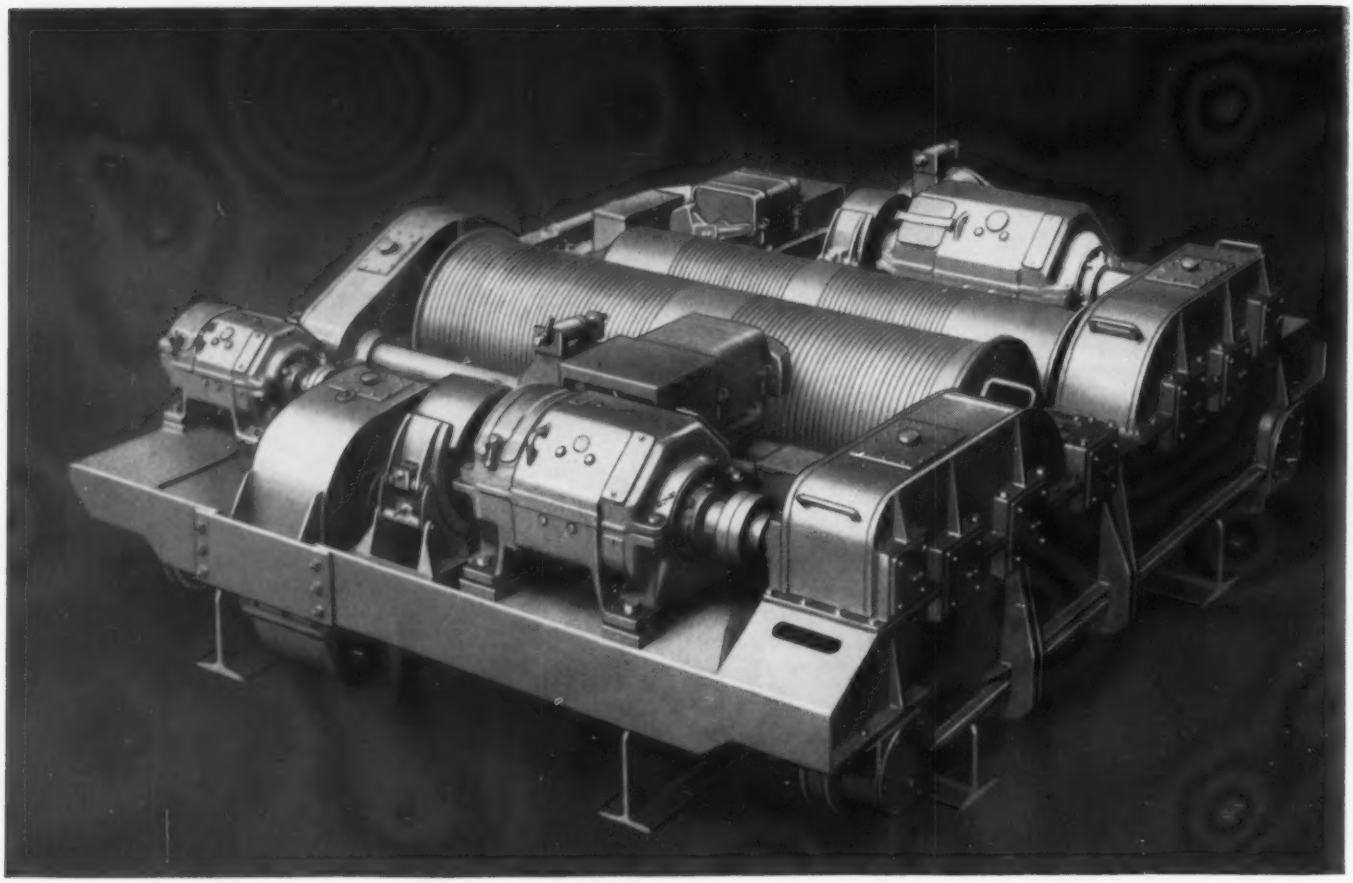
The next step for many of these metal producers will be the linking together of "islands of automation." By application of General Electric automatic computer-control equipment, greatly improved programming for an entire sequence of processes will result. All operations can then be effectively measured and evaluated early enough to allow modifications that will quickly satisfy conditions in any individual process. An entire production area will become responsive to directives originating from a central source.

Finally, as production areas are linked by a master computer-control system, completely automatic production scheduling and manufacturing throughout the entire plant will result. Over-all performance will be in direct accord with management decisions based on incoming orders, related process operations, materials inventories and all of the many complex variables that determine profitable plant operation.

Let General Electric begin working with you now in your planning for future profits. You'll find that the capability to provide the ultimate in automation is a reality at General Electric today. For more details, call your nearest Apparatus Sales Office. General Electric Company, Section 659–131, Schenectady 5, New York.

AUTOMATION THROUGH MODERNIZATION

GENERAL ELECTRIC



VICTOR R. BROWNING *Trolleys*

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"Simple Design is Sound Design"

We offer a complete line of trolleys built to meet the most exacting requirements. These trolleys are constructed of the finest materials available. No cast iron is used. All shafts are of highest quality alloy steel. All bearings are calculated with a proper life factor for service required as defined by the A. I. S. E. We will build a trolley to fit your special requirements as to gauge, head room, approaches and general arrangement. We also make a complete line of cranes for steel mill use. . . Your inquiries will be welcome.

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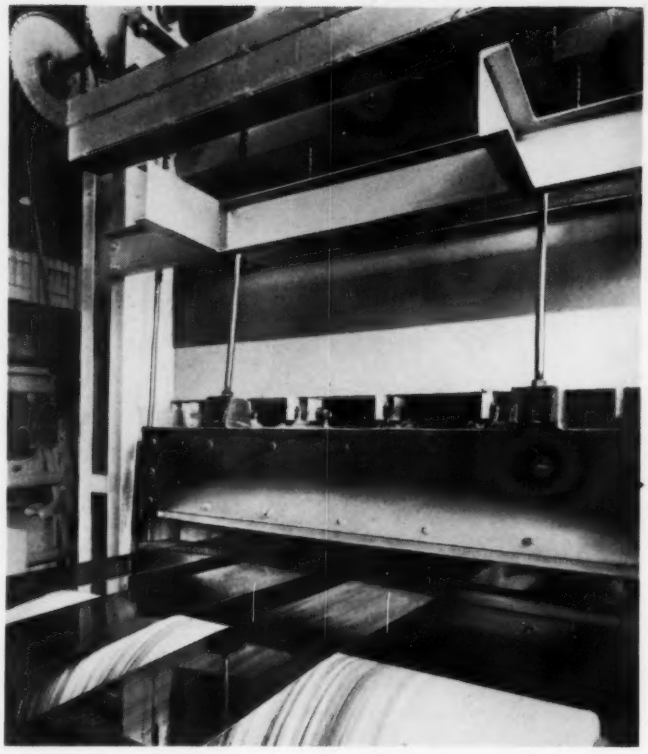


Figure 1 — Mirror-bright stainless steel enters the gas-fired annealing furnace through precisely-regulated opening during the processing cycle of the new annealing and pickling line. The doors of the furnace are set to control the atmosphere within the chamber, and are opened only when necessary. Installation of this and other equipment in the new line nearly triples the stainless strip capacity of the J&L plant.

J&L Installs Annealing And Pickling Line At Youngstown Plant

THE installation of a new annealing and pickling line at the Youngstown plant of the Jones & Laughlin Steel Corp.'s stainless and strip division has virtually tripled the stainless steel strip production capacity of the plant.

The new line will be used primarily for annealing and pickling JL430 moulding quality stainless steel strip for automotive and other applications. Secondary use will be for annealing and pickling the chrome-nickel 300 grades of stainless strip.

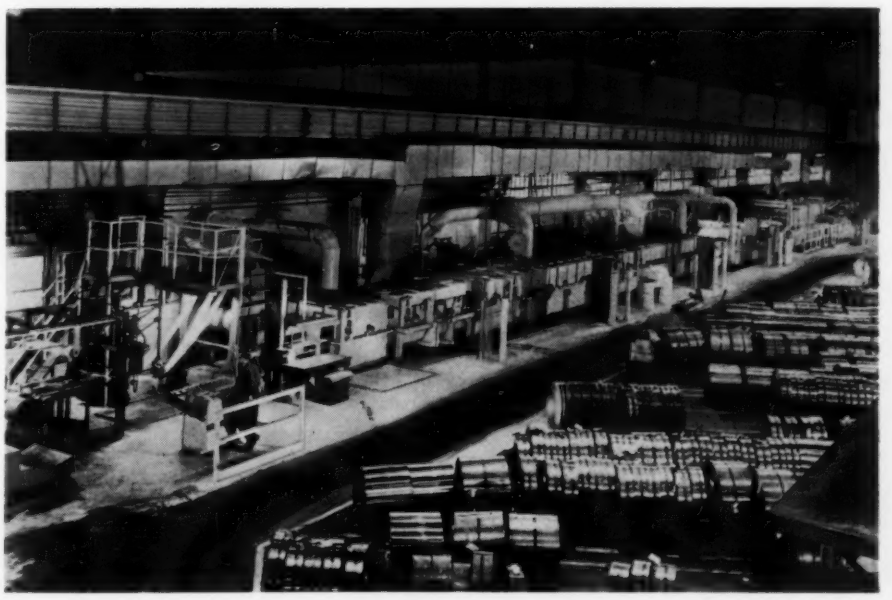
Prior to this installation, J&L annealed and pickled stainless sheet and strip at its Louisville, Ohio, plant only except for a special stainless bright annealing process at the Youngstown plant. This line will make the Youngstown plant one of the few facilities in the country capable of producing all types of finishes on annealed stainless strip.

The line is equipped with three uncoilers and may be set to process 8, 12 or 24-in. widths of stainless in three, two or one-strand operations, respectively.

The annealing temperatures range between 1500 F for the 400 grades to more than 2100 F for the 300 grades. Annealing is followed by a Kolene salt descaling treatment and two acid baths in electrolytic pickle tubs.

The Youngstown line is equipped with torque motors for helper drives on individual rolls throughout the length of the line. The torque motors prevent skidding and eliminate scratching during the operation. ▲

Figure 2 — Jones & Laughlin Steel Corp.'s new annealing and pickling line, installed at Youngstown, Ohio, plant of the stainless and strip division, is used to anneal and pickle primarily Type 430 molding quality stainless strip for automotive and other applications.



Another example of National Roll quality control

John Patton, National's assistant sales manager and Joe Marsalka, metallurgist, look over the reflectoscope "profile" of a steel roll.

No flaw escapes this electronic eye!

Your steel rolls from National are given a thorough examination by reflectoscope before shipment. Ultra-high frequency sound waves traverse every segment of the roll, electronically assuring the absence of internal flaws which might shorten the roll's service life in your stand.

This attention to detail and emphasis on high quality of product are two reasons why more and more steel makers are turning to National for their steel, iron and nodular iron rolls. From the moment you call a National representative, your roll problem gets the *personalized* attention of men experienced in analysis, design and production.

We'd like to tell you more about how National Roll's expanded staff and facilities can serve you. Next best thing to a visit with us is a look at our new brochure. May we send you a copy? It helps explain why . . .

National's the growing name in rolls

NATIONAL ROLL & FOUNDRY DIVISION

GENERAL STEEL CASTINGS CORPORATION, Avonmore (Westmoreland County), Pa.

General Steel Castings Corporation, General Offices: Granite City, Illinois • Plants: Granite City, Ill., Eddystone, Pa., Avonmore, Pa.

Sand Ring Formulation for Open Hearth Hot Top Practice

by G. M. CORBETT, and R. H. COOPER,
Technical Service and Development, The Dow Chemical Co., Midland, Mich.

IN hot top practice, which is widely used throughout much of the steel industry, a silica sand refractory ring is inserted between the hot top and the ingot mold to prevent liquid steel from contacting the lower end of the hot top casing. The ring is attached to the lower end of the hot top casing by means of wire clips. These rings are supplied in a wide variety of sizes to fit the many different ingot molds now in use.

The past decade has seen many significant developments and improvements in the field of plastics and synthetic resins. This is particularly true in the field of structural plastics where high strength combined with excellent protective qualities are concerned. Of the commercial resins, the phenolics are probably the most commonly known and although they are not new in type, nevertheless many new phenolic resin systems have been developed during the past few years.

Some phenolic resins, when applied in the proper manner, are excellent binders for such media as fibers, coke, wood, sand and many others. When thoroughly cured, many phenolics are strong, dimensionally stable and impervious to many solvents, particularly water. One short-coming which is common to nearly all synthetic resins is their inability to withstand elevated temperatures. However, it is possible to tailor-make phenolic resin formulations so as to greatly improve their resistance to both heat and thermal shock.

The requirements for hot top refractory rings may be summed up as follows:

1. They must be economical.
2. They must have good permeability.
3. They must neither emit nor create any toxic materials.
4. They must not soften when exposed to 600 to 800 F for two or three hours.
5. They must be strong enough to withstand shipping and handling.
6. They should not be adversely affected by moisture.

It is possible to make good hot top refractory rings using silica sand bonded with a water-borne liquid phenol-formaldehyde resin. The resin found to be most satisfactory for this application is a "one-stage" resole resin containing 60 per cent solids with a formaldehyde to phenol ratio of about 1.45.

Of many sands tested, several were found to be very satisfactory giving good bond strengths along with good permeability. The use of a fine sand is undesirable because it increases resin consumption and also reduces permeability and retards the escape of gases. One particular sand found to be very good for this application is a No. 7 Portage sand from Phalanx, Ohio. This is a crude commercial sand having an AFS fineness of 33.

It was found that particular types or grades of magnesium oxide can be used to initiate and control the polymerization of a water soluble liquid phenolic resin upon an aggregate. Not only does the magnesium oxide cause auto-hardening of the resin at room temperatures within a very short time, but also the polymerized product is more resistant to thermal shock. However, even the magnesium oxide catalyzed product does not possess sufficient heat resistance to prevent loss of structural strength when exposed to temperatures in the order of 600 F for two to three hours. This problem was overcome by incorporating equal amounts of soda ash and magnesium oxide into the formulation. Specimens made from this formulation will retain considerable strength when heated to 1800 F for one hour. In general, the amount of both the magnesium oxide and soda ash used was approximately 10 per cent of the liquid resin weight.

Although structurally sound specimens can be made using sand containing as low as 1.8 per cent by weight phenol formaldehyde resin (calculated on solids basis), a superior product can be obtained using resin concentrations in the order of 2.5 to 3.5 per cent.

The ingredients are mixed by mulling in a manner similar to mulling foundry sand formulations. The wet mixture is rammed into a mold of desired shape and then baked to effect the resin cure. Mulling time is approximately seven minutes. Baking temperatures may range from 375 to 500 F with the lower temperatures requiring longer cure times. At 500 F the cure time can be reduced to 20 to 30 min depending on the size of the ring.

It appears that core blowing techniques can be adapted to the production of these resin bonded sand rings. Several different formulations were tested on commercial foundry core blowing equipment with very good results. Working time of the wet resin mix is in some cases rather short, but this can be controlled within limits by the type or grade of magnesium oxide employed. For example, auto-hardening times from 15 min to 48 hr may be obtained without any appreciable change in tensile strength of the end product. Soda ash has virtually no effect on auto-hardening time.

Several of these resin-bonded

sand rings at various levels of resin concentration have been field tested in the open hearth shop of one of the major steel mills. The rings tested were 27½ x 27½-in. square and the metal was a fully killed 45 carbon, 35 sulphur max steel. The ingots were 6-ton big end up with about a 15 per cent volume of hot-topped steel. The hot-top casings were pulled from the ingot two hours after pouring and the bottom edge of the hot-top casings were cool indicating that the rings did a good job of insulation.

In general, the performance of these rings was very satisfactory. One desirable feature is the fact that at steel pouring temperatures, resin burn-out is complete so that when the hot-top casing is pulled from the ingot, the sand ring disintegrates leaving a clean ingot with no pieces to litter the area or stick to the ingot. Rings were tested both with and without a re-enforcing wire imbedded in the center. It is felt that re-enforcing wires would not be necessary except as a precaution in the low resin formulation (less than 2.4 per cent resin solids) to help minimize breakage loss during shipping and handling.

It is rather difficult to obtain accurate economic data on resin bonded sand rings without conducting more fabrication research. However, it should not be difficult to produce these rings in a manner similar to foundry cores. It appears that a continuous manufacturing operation could be set up consisting of automatic metering of the constituents followed by mechanical mixing and core blowing. The green ring would then be cured for 15 to 30 min at approximately 500 F after which it is ready for use. ▲

Recent Improvements In Cleaning Open Hearth Checkers

UNTIL recently, Great Lakes Steel Corp. of Ecorse, Mich., a division of National Steel Corp., cleaned its open hearth furnace hot brickwork "checkers" with 100 psig air. Now they use high pressure water.

This high pressure water is supplied by a portable trailer-mounted pumping rig. The rig was designed and assembled by Worthington Corp. and consists of a Worthington plunger pump directly connected to a 40-hp TEFC Falk motor reducer.

At best, the air cleaning of the furnace "checkers" was only fair. A gradual build-up of foreign matter not removed by the air blast required a manual cleaning job on the "checkers" after approximately three months. Manual cleaning can only be accomplished with the furnace shutdown.

When a furnace was shutdown, it took about eight days to replace the roof refractory and manually chisel off the build-up on the "checkers."

Manual cleaning has practically been eliminated and downtime at rebuild reduced substantially. Many times "checkers" are only opened for inspection.

The pump has a capacity of 57 gpm and operates at 280 rpm. Water is supplied from the mill water supply lines to the pump, which discharges its full capacity to a multi-orifice cleaning nozzle at 970 psig through a 25-ft long lance.

The lance is inserted into the checker banks where the high pressure water spray pattern from the nozzle removes the accumulated deposits of iron ore, slag dust, carbon and other foreign matter from the "checkers."

It is reported that both checker banks for one open hearth furnace are now cleaned in one eight-hour turn and it is expected that the crew will eventually be able to take care of two furnaces a day. ▲

Figure 1 — The high pressure water pumping rig is mounted on a four-wheel, pneumatic tired trailer, complete with motor starter, pump by-pass control system and a length of high pressure hose.

Figure 2 — The high pressure water pumping rig consists of a 2¼ x 4, vertical triplex, single acting plunger pump, directly connected to a 40-hp motor reducer.

SCHLOEMANN

18 Aluminum Cable Sheathing Presses in two Years

Operational sequence of the SCHLOEMANN aluminum cable sheathing press is now fully automatic, in continuous cycles. Sheathing thickness is held to specification even though extrusion may be interrupted. This press is an outstanding example of many successful innovations accomplished by SCHLOEMANN in connection with the plastic deformation of steel and non-ferrous metals. *Write today for descriptive literature.*

FELLER ENGINEERING COMPANY 1161 Empire Building, Pittsburgh 22, Pa.

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View of One Bay in the New Research Building
Showing the Continuous Strip and Bell Furnaces.

THE ELECTRIC EF FURNACE CO.
GAS • OIL • ELECTRIC

completely equipped
Research Department

to develop and test improved heat treating techniques benefitting ALL metal producers and fabricators . . .

From the company's earliest beginning research has been traditional at The Electric Furnace Co.

Recently our facilities have been much enlarged. Our research department now has its own building, 180 feet long by 80 feet wide. Equipment includes a continuous strip furnace suited for processing at various cycles; bell, wire mesh belt, batch and pusher furnaces, with and without forced circulation; vacuum furnaces for batch or continuous operation; endothermic and exothermic generators; ammonia dissociators; atmosphere refrigerators; adsorption type gas dryers; CO_2 scrubbers, and completely equipped chemical and metallurgical laboratories.

From these larger facilities are coming improved techniques for treating the familiar materials, and new techniques for treating the newer metals of the jet and space age;— also expanded testing of critical materials used in our furnaces, to maintain our unsurpassed standards of quality and performance.

As in the past, our research facilities will be available to **all** metal producers and processors, for development and test work, conducted, if desired, in the presence, and with the assistance of your own technical men.

This complete and modern laboratory is as close to you as your telephone. Feel free to use it frequently!

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THE ELECTRIC FURNACE CO.

Gas-fired, Oil-fired and Electric Furnaces for Heat Treating any Product, Using any Process, any Hourly Output.

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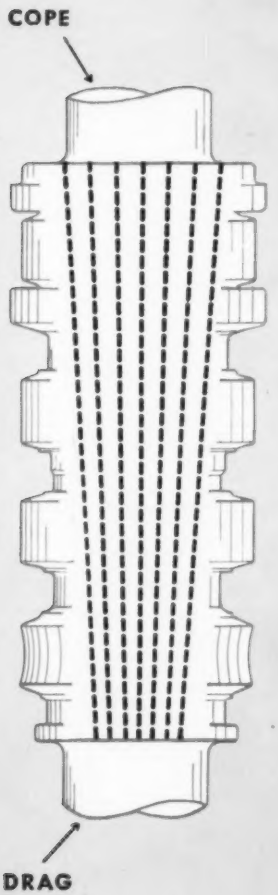
TIPS FROM A ROLL MAKER'S NOTEBOOK

MACKINTOSH-HEMPHILL DIVISION, E. W. BLISS COMPANY, Pittsburgh 3, Pennsylvania

Cast mill rolls • Johnston cinder pots • rotary tube straighteners • end-thrust bearings • heavy-duty lathes • steel and special alloy castings

With rolls, it pays to know which end is "up"



Cast steel structural mill roll shows good pass location to promote proper directional solidification.

There's a very good reason why every roll shipped by Mack-Hemp carries the word "DRAG" engraved on one wabbler. With all cast rolls, maximum strength and depth of sound metal tend to occur toward the *drag* end of the roll—the end at the bottom of the mold when the roll is being poured. This is because of the normal manner in which the "lines of solidification" form as the molten metal cools and solidifies. Also the pressure from the weight of the metal above helps increase the density of the metal in the drag end of the roll.

As you can see from the diagram at the left, the solidification lines angle gently outward as they rise toward the top or "cope" neck of the roll, forming a cone-shaped pattern. In general, these lines of solidification mark the boundary of the dense, homogeneous metal. As a result, there is more good metal in and near the drag end than at the cope end. To assist the roll user in quickly identifying the "bottom" end of his rolls, Mack-Hemp brands the drag wabbler of every roll produced in its foundries.

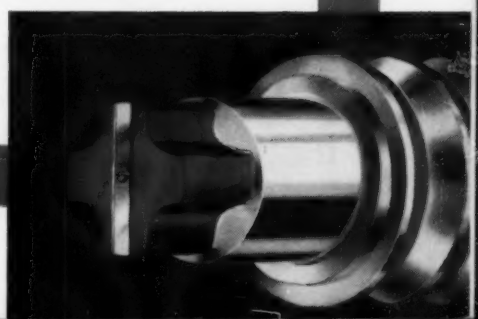
Locate the deepest passes in the DRAG end—Roll designers making drawings for blooming, rail and structural mill rolls should try to locate the deepest passes in the driven end of the roll, as illustrated. Directional solidification from drag to cope is then more easily accomplished and a sounder casting results.

We don't mean to imply that deep passes cannot be located at the cope end of the roll—in some instances, the overall mill layout, flow to the next mill, etc. may make it necessary to have the deepest pass in the cope end. When possible, however, this should be avoided since a deep pass in the cope end of the roll will restrict proper feeding of the lower portion of the roll.

Another factor—For maximum roll life, roll blueprints should call for the deepest passes at the driven end of the roll body. If you have a special reason why they must be located elsewhere, note it on the drawing; otherwise any roll maker worth his salt will ask you about it.

Another good rule to follow is to check with Mack-Hemp on any problem of roll selection or application. In a century and a quarter of making mill rolls, we have run across just about every conceivable situation involving the use of rolls. Our advice is yours for the asking. Feel free to telephone or write us at any time.

An important legend... for maximum roll life, the drag wabbler should be driven.



MACKINTOSH-HEMPHILL

You get more tonnage from the rolls with the Striped Red Wabblers

Division of E. W. BLISS COMPANY

Presses, Rolling Mills, Special Machinery

EC&M Electrical Control fo

1800-Ton-per-Hour Dravo Unloader in operation at Pennsylvania Railroad's Greenwich Point, Philadelphia, Ore Unloader Pier

Square D Field Engineering Service is available through more than one hundred Square D offices, backed by an international network of over 1000 authorized electrical distributors and 19 plants in the United States, Canada, Mexico and England

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SQUARE D COMPANY

EC&M DIVISION • CLEVELAND 28, OHIO

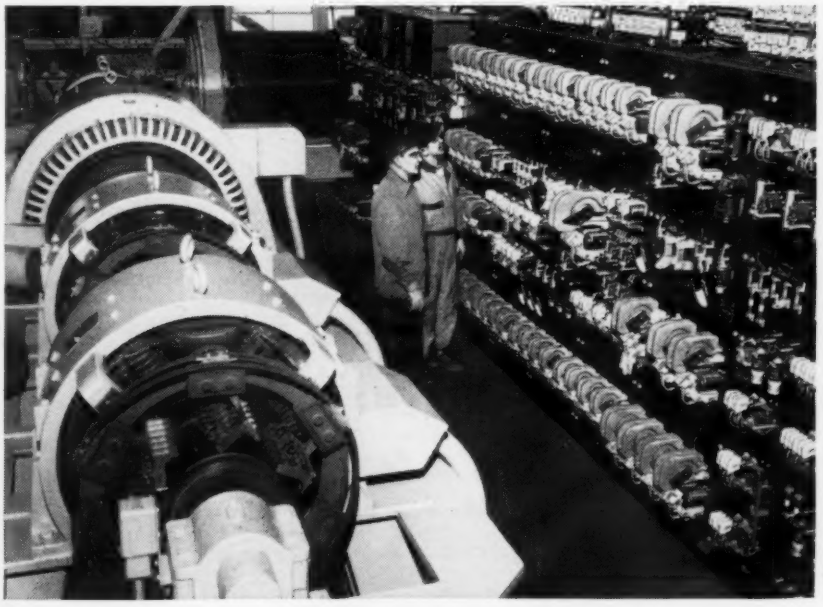
ol for Industry's Big, Tough Jobs!

22½ TON BITES!

Everything about this ore unloader is big... and it does a big job with amazing speed. Powered through 20 motors ranging in sizes up to 800 HP, it takes 22½ tons of ore from a ship's hold on an average cycle handling time of 45 seconds!

Electrical control equipment does a big job, too, in putting this unloader through its paces. And there's a lot of it. Hoist control, trolley control, bridge control brakes. *All of it is EC&M.*

Consult EC&M when planning adjustable voltage installations

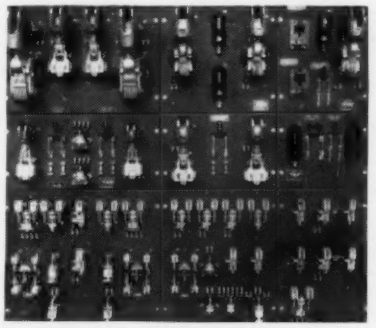


Here is an example of EC&M's control and engineering service in action. These EC&M control panels are mounted in the machinery room, 100 feet above ground level, along with generators which supply DC power for unloader motors. EC&M is geared to supply the complete job including rotating machinery for adjustable voltage and constant potential drives.

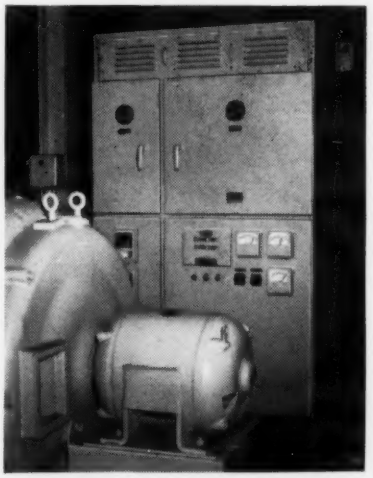
Photos courtesy Dravo Corporation, Elliott Company, and the Pennsylvania Railroad

wherever electricity is distributed and controlled

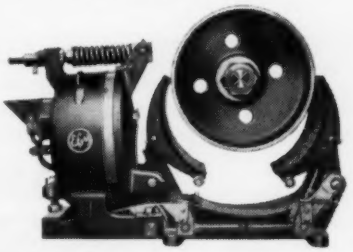
EC&M PERFORMANCE-PROVEN
CRANE EQUIPMENT



EC&M Adjustable Voltage Control Panel (mounted on trolley) for Hold and Close Line Motors and for Trolley Motor, plus Protective Panel for other drives



EC&M Type ZHA 4160 Volt Starter provides pushbutton starting of 800 HP Elliott synchronous motor driving 4 generators



EC&M Type WB Brakes—designed for fast response in releasing and setting. 100% lubrication insures exceptionally long life

2 worn-out spindles received early Sunday... 2 rebuilt spindles in service Monday morning, 600 miles away!

The customer was in Greenville, South Carolina working on a time contract with stiff penalties for failing to meet the deadline. The spindles on two of their most important machine tools failed almost simultaneously and there were no spares available.

Our subsidiary, Dixie Bearings, Inc., was called late Saturday; our Spindle Repair Department in Cleveland alerted and, with the cooperation of Eastern Airlines, the spindles were in our shop early Sunday. By working all day Sunday, the spindles were back in Greenville and in operation on Monday morning!

This is only one of the many bearing services we provide. For fast help in solving any problem involving bearings—for quick delivery of any nationally known make of bearing—call the branch nearest you, day or night!

Providing bearing service in the North ➤ **BEARINGS, INC.**

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and in the South ➤ **DIXIE BEARINGS, INC.**

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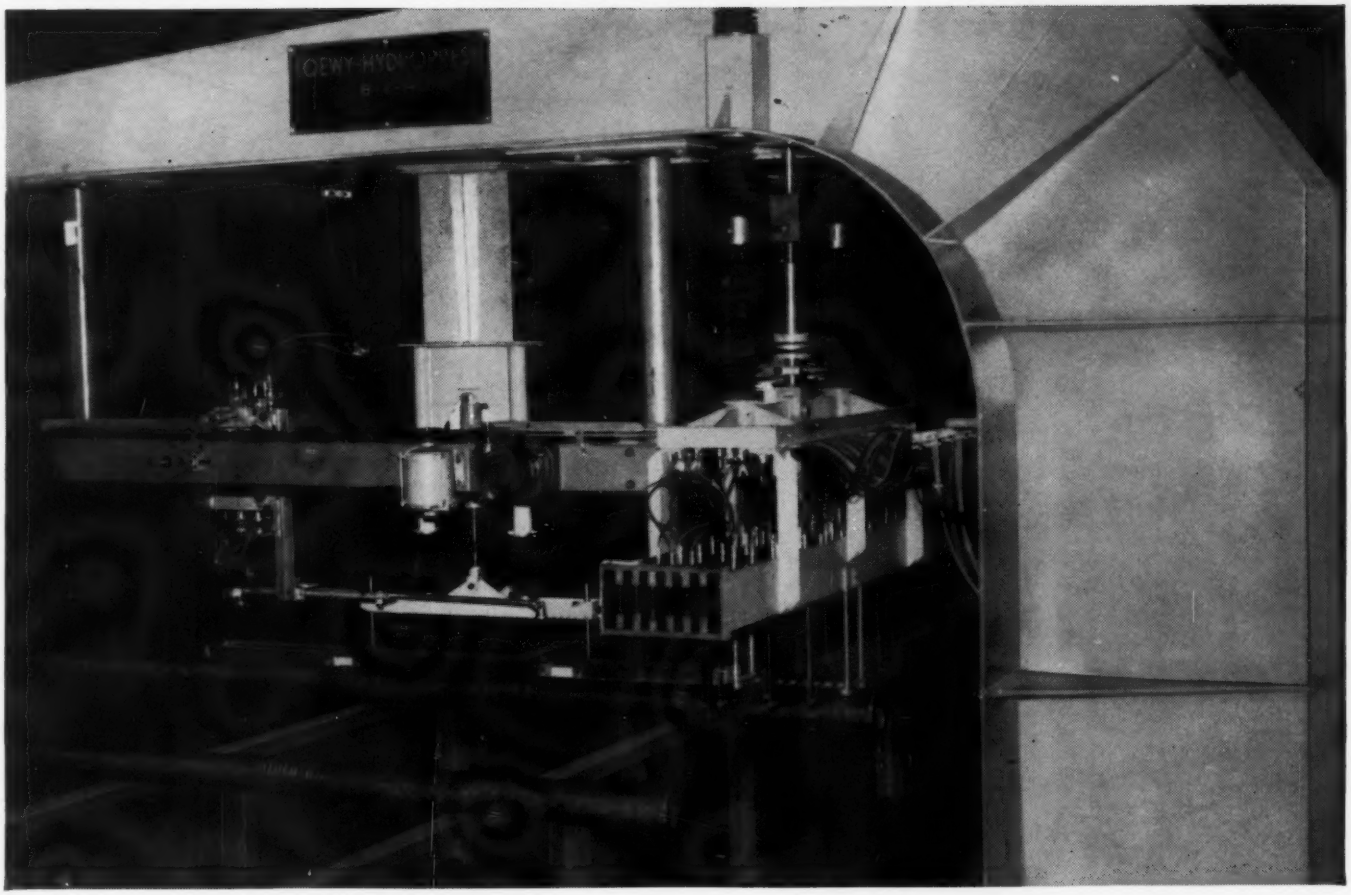


Loewy-built automatic pipe counting, measuring, weighing, stenciling and recording machine in operation.

Now! Loewy brings **AUTOMATION** to steel pipe data processing!

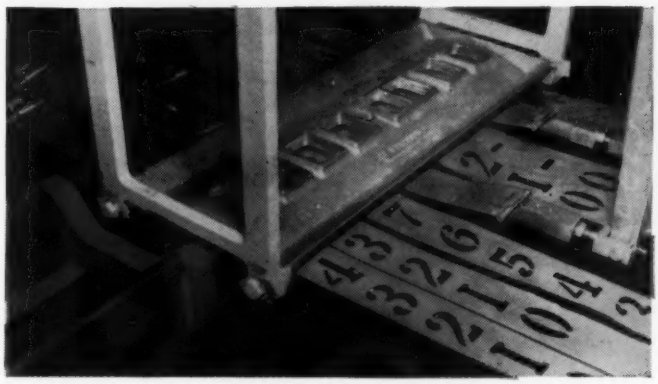
Until very recently, steel pipe data processing demanded large crews, costly training, strict coordination, continuous supervision.

The new Loewy system, however, handles the many steps involved *automatically:*

- Weighs each pipe by means of B-L-H load cells.
- Measures pipe length.
- Stencils these variables on each pipe, in addition to fixed data, in conformance with A.P.I. standards.
- Computes weight per foot for each pipe.
- Rejects pipes out of weight tolerance.
- Indicates and prints the cumulative number of pipes, the individual and cumulative total lengths and weights, the time, the date, and pre-set data for each pipe.

Electromechanical instrumentation provides visual readouts, signals at values of count, total or individual weight or length, upper and lower limit of tolerance, or any other measured or calculated quantity. These signals may be used to operate relays, alarms, reject devices, to close down the line, to position cut-off devices, or whatever is required. And all this is done as an integral part of the mill production line.

Two of these Loewy robots are already in successful operation at a leading Midwestern steel mill, each handling 7 miles of heavy steel pipe in one 8-hour shift with ease. A third is now on order.



Close-up view of variable message stenciling section.

Loewy data gathering and processing equipment is not limited to tubular products. It can be used in any process which involves linear measurement, weighing, calculated quantities depending on these measured variables, automatic error-proof stenciling and printing of tally sheets, shipping information, inventories, production and incentive records, card or tape punching.

We shall be glad to explore the usefulness of Loewy pipe processing equipment for your plant. Write Dept C-5.

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INDUSTRIAL EQUIPMENT DIVISION • PHILADELPHIA 42, PA.

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Don't let anyone tell you that good steel abrasives can't be made at lower cost. METAL BLAST is doing it — and passing the savings along to YOU! An entirely new manufacturing method does away with costly equipment and processing used by others — turns out a product meeting rigid steel tests and guaranteed to equal the performance of any steel abrasive on the market. So, don't let the price suggest otherwise! "SUPER-STEEL" is top quality steel shot and grit and cleans as top quality abrasives should. At $165 per ton, you can save many important dollars. A trial will prove it! Write, wire or phone (collect) for further information, trial order or free testing sample.

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Date-line Diary...

April 1

△ The NMTBA reports that new orders of metal-cutting and metal-forming type machine tools in 1959 totaled $658,950,000 compared with $374,300,000 in 1958; shipments in 1959 totaled $538,150,000 against $519,900,000 in 1958.

April 4

△ The AISI reports that the operating rate of the steel industry for the week of April 4 is scheduled at 2,447,000 tons (85.9 per cent of capacity). This compares with 2,527,000 tons one week ago (88.7 per cent capacity) and 2,641,000 tons one year ago. Index of production for the week is 152.3.

△ A wildcat strike over the suspension of four union members for allegedly refusing work assignment ended at Pittsburgh Steel's Allenport plant after idling the plant for 4½ days and involving 2600 workers.

△ Production and maintenance workers at Lone Star Steel Co., Daingerfield, Texas, plant voted 2640 to 667 for the USW union as bargaining agent.

△ Auto assemblies for March totaled 654,252 units compared with 576,083 in March, 1959; production in the first quarter of 1960 totaled 2,002,240 cars compared with 1,600,357 in the first quarter of 1959.

△ Universal Cyclops Steel plans capital outlays of $36,000,000 in 1960–61, for which they are considering sale of a block of stock.

April 5

△ Atlas Steels Ltd. reports for the year 1959 net income totaling $3,288,961 or $3.02 per common share compared with income of $2,209,924 or $2.04 per share in 1958.

△ Britain's government presented a $16,000,000 budget to Parliament. The budget raised some taxes, including the levy on corporate taxes, cut or wiped out a few, and called for curbs on tax evasion.

△ The Bureau of Mines reported that production of Pennsylvania anthracite for March, 1959, was 1,648,000 net tons compared with 1,579,000 net tons in February, 1960, and 1,508,000 net tons in March, 1959.

April 6

△ The Aluminum Assn. reports that shipments of aluminum sheet and plate in February, 1960, totaled 109,135,000 lb compared with 106,971,000 lb in January, 1960; shipments of aluminum foil in February, 1960, totaled 19,082,907 lb compared with 17,593,430 lb in January, 1960.

△ The U. S. Dept. of Commerce reports that production of titanium mill products in February, 1960, totaled 497,701 lb, compared with 796,538 lb in January, 1960, and 477,745 lb in February, 1959. Production of titanium ingots totaled 967,850 lb in February compared with 965,414 lb in January.

April 7

△ Republic Steel announced it will reopen its large diameter pipe mill at Gadsden, Ala., on April 12 to fill a "substantial" order.

△ The AISI reports that shipments of finished steel productions in February, 1960, totaled 7,583,033 net tons, compared with 6,524,374 tons in February, 1959.

△ Joint report of the American Iron Ore Assn. and AISI indicates receipts of iron ore and iron ore agglomerates in the U. S. in February, 1960, totaled 4,430,906 gross tons compared with 3,040,248 tons in February, 1959; stocks on hand on February 29, 1960, amounted to 42,482,696 gross tons compared with 46,473,149 gross tons on February 28, 1959; 231 of the total 258 U. S. blast furnaces were operating on February 29, 1960, compared with 215 going on February 28, 1959.

△ Reserve Mining Co., Silver Bay, Minn., jointly owned by Republic Steel and Armco Steel, plans to boost its taconite capacity by 60 per cent over present output of 5,500,000 tons of pellets annually, contingent upon approval of settlement of dispute between Reserve and Mesabi Iron Co. by the Mesabi stockholders.

April 8

△ Youngstown Sheet and Tube cut output shutting down the Hubbard blast furnace and three open hearths at Youngstown.

April 11

△ The Patterson-Emerson-Comstock, Inc., will dismantle, ship, and re-erect the Gary (Ind.) armor plate mill for Cooperativa de Provision de Industriales Metallurgicos Ltd., Argentina, as the first phase of an $84,000,000, five year project for the design and construction of a rolling mill.

△ Detroit steel shareholders approved offer to exchange Portsmouth Corp. common stock for Detroit Steel common stock at the rate of 1.55 shares of Detroit Steel for each share of Portsmouth.

△ The AISI reports that the operating rate of the steel industry for the week of April 11 is scheduled at 2,277,000 tons (79.9 per cent of capacity). This compares with 2,417,000 tons one week ago (84.8 per cent capacity) and 2,657,000 tons one year ago. Index of production for the week is 141.7.

April 12

△ The Labor Dept. reported that unemployment in mid-March showed an increase of 200,000 to a total of about 4,150,000.

April 13

△ The U. S. Dept. of the Interior, Bureau of Mines, reported that consumption of scrap in February, 1960, totaled 6,497,000 gross tons compared with 7,043,488 tons in January, 1960; pig iron consumed in February, 1960, totaled 6,605,000 gross tons compared with 7,015,000 tons in January, 1960.

△ General Electric Co. reported for the first quarter of 1960, sales totaling $957,433,000, net earnings amounting to $52,614,000 or 60¢ a share, compared with the first quarter of 1959, sales $976,568,000, net profit $52,778,000, or 60¢ a share.

△ Bureau of the Census reports that shipments of steel forgings for the year 1959 totaled 1,373,801 short tons, compared with 1,079,547 tons in 1958; unfilled orders at December 31, 1959, totaled 420,118 short tons compared with 313,057 tons on December 31, 1958.

April 15

△ The Bureau of Census reports that shipments of commercial steel forgings during February, 1960, totaled 129,890 short tons, compared with 122,551 tons in January, 1960, and 112,658 tons in February, 1959; backlog on February 29, 1960, was 399,220 short tons compared with 420,102 tons on January 31, 1960, and 392,054 tons on February 28, 1959.

△ Copper on the London Metal Exchange last week rose slightly more than 1¢ a lb to 33.31¢; it advanced 0.675¢ to 32.425¢ a lb at New York and Antwerp.

△ Republic Steel purchased from the U. S. Government the blast furnace and related equipment, which it has been operating since 1944, at Youngstown; and sintering facilities, operated for the Government, at Warren. Price paid was $3,449,039; the original cost of the facilities was $9,121,201 for the Youngstown operation and $1,037,429 for the Warren plant according to the GSA.

△ Westinghouse Electric Corp. reported that in the first quarter of 1960 sales totaled $458,817,000, net income $19,496,000 or 55¢ a share compared with sales totaling $440,072,000, net income of $14,409,000 or 41¢ a share for the first quarter of 1959.

△ The AISI reports that the operating rate of the steel industry for the week of April 18 is scheduled at 2,305,000 tons (80.9 per cent of capacity). This compares with 2,225,000 tons one week ago (78.1 per cent capacity) and 2,646,000 tons one year ago. Index of production for the week is 143.5.

△ The Reading Tube Corp. reported for the year 1959 sales amounting to $23,316,775, net earnings totaled $859,650 or 99¢ a share, compared with sales totaling $18,412,497, net profit of $986,347 or $1.16 a share in 1958.

April 18

△ The Bureau of the Census reports that receipts of aluminum pig and ingot in February, 1960, totaled 105,084,000 lb; net shipments totaled 172,485,000 lb in February, 1960, compared with 122,500,000 lb in January, 1960, and 100,527,000 lb in February, 1959.

April 20

△ The AAR reports that deliveries of new freight cars in March, 1960, totaled 5950, compared with 5052 in February, 1960, and 2797 in March, 1959; new orders in March, 1960, amounted to 1959 compared to 3411 in February, 1960, and 10,792 in March, 1959. Backlog of cars on order as of April 1, 1960, totaled 42,131 compared with 46,323 on March 1, 1960, and 35,487 on April 1, 1959.

△ The Aluminum Assn. reports production of primary aluminum in the United States in March, 1960, totaled 170,658 short tons compared with 156,826 tons in February, 1960, and 157,189 tons in February, 1959.

April 21

△ National output of goods and services in the quarter ended March 31, 1960, rose to a seasonally-adjusted annual rate of $498,000,000,000, a gain of $14,500,000,000 over the pace in the final quarter of 1959, and compared with actual output of $479,500,000,000 in 1959.

△ Directors of Lone Star Steel Co. approved a 10 per cent stock dividend; stockholders authorized an increase in the number of $1 par shares from 3,567,080 to 3,923,788.

April 22

△ Allis-Chalmers Manufacturing Co. reported, for the first quarter of 1960, sales totaling $126,392,931, net profit $2,645,273, equal to 28¢ a share compared with sales amounting to $84,125,133, net loss of $3,623,466 or 43¢ a share for the first quarter of 1959.

April 25

△ Pittsburgh Steel Co., board of directors declared a dividend of $1.375 per share on the prior preferred stock, and $1.25 per share on Class A, 5 per cent preferred stock to shareholders on record on May 6, 1960.

△ The AISI reports that the operating rate of the steel industry for the week of April 25 is scheduled at 2,261,000 tons (79.4 per cent of capacity). This compares with 2,238,000 tons one week ago (78.5 per cent capacity), and 2,627,000 tons one year ago. Index of production for the week is 140.8.

April 26

△ Resistance Welder Mfr. Assn. reports that shipments of resistance welding equipment during March, 1960, exceeded $3,000,000, up 17 per cent over February, 1960; for the first quarter of 1960 shipments increased 30 per cent, and bookings 25 per cent over the same period in 1959. At the end of March, 1960, backlogs amounted to almost $12,500,000.

△ The AISC reports that shipments of fabricated steel products in March, 1960, totaled 276,977 tons compared with 240,850 tons in February, 1960, and 260,490 tons in March, 1959. Bookings in March, 1960, totaled 342,859 tons compared with 288,825 tons in February, 1960, and 254,773 tons in March, 1959. Backlog on order as of March 31, 1960, amounted to 2,364,390 tons.

△ The Bureau of the Census reports shipments of

STEEL COMPANIES FINANCIAL REPORTS—QUARTER ENDING MARCH 31, 1960

	Period	1960 Net sales	1960 Net profits	1960 Earnings per share	1959 Net sales	1959 Net profits	1959 Earnings per share
Acme Steel Co.	1st quar.	$ 46,851,347	$ 2,092,522	0.72	$ 40,109,575	$ 1,925,493	0.67
Alan Wood Steel Co.	1st quar.	20,242,539	854,995	1.14	18,468,075	955,264	1.29
Allegheny Ludlum Steel Corp.	1st quar.	79,672,618	4,791,584	1.24	70,276,087	4,549,542	1.18
Armco Steel Corp.	1st quar.	274,308,574	23,957,994	1.62	259,249,797	21,152,038	1.43
Bethlehem Steel Co.	1st quar.	655,821,014	51,828,727	1.10	615,929,580	49,567,301	1.06
A. M. Byers Co.	1st quar.	6,250,130	11,700	...	5,994,546	220,200	0.19
	6 mos.	12,916,610	132,700	0.14	11,455,755	495,400	0.44
Carpenter Steel Co.	1st quar.	23,000,693	1,839,428	0.96	18,136,162	1,168,635	0.62
Colorado Fuel and Iron Corp.	1st quar.	.....	2,846,692	0.72	.....	4,604,840	1.30
Continental Steel Corp.	1st quar.	13,218,264	1,135,414	1.10	12,932,529	1,081,030	1.05
Copperweld Steel Co.	1st quar.	36,140,542	1,389,174	1.18	33,476,134	1,501,255	1.32
Crucible Steel Co. of America	1st quar.	71,633,919	2,724,798	0.67	66,483,130	3,511,206	0.93
Detroit Steel Corp.	1st quar.	34,366,105	3,501,088	1.15	23,789,443	2,568,313	0.83
Eastern Stainless Steel Corp.	1st quar.	18,355,557	1,071,000	0.54	16,190,775	891,000	0.47
Edgewater Steel Co.	1st quar.	4,579,704	163,264	0.87	4,155,188	153,168	0.82
Firth Sterling, Inc.	1st quar.	5,904,800	(179,900)	...	5,476,200	101,700	0.06
	6 mos.	12,092,400	(160,800)	...	9,592,200	(112,100)	...
Granite City Steel Co.	1st quar.	42,423,656	4,320,655	1.01	37,538,764	3,484,763	0.81
Green River Steel Corp.	1st quar.	4,741,958	412,026	...	3,366,623	176,000	...
Inland Steel Co.	1st quar.	227,565,809	18,743,934	1.07	211,915,807	17,859,090	1.03
Interlake Iron Corp.	1st quar.	27,828,679	1,862,848	0.83	31,725,752	2,119,203	0.95
Jessop Steel Co.	1st quar.	10,414,687	547,735	0.85	6,125,641	457,892	0.77
Jones & Laughlin Steel Corp.	1st quar.	254,424,000	17,794,000	2.22	236,384,000	15,738,000	1.97
Kaiser Steel Corp.	1st quar.	64,987,105	6,686,660	1.79	61,029,973	3,302,687	0.76
Keystone Steel & Wire Co.	1st quar.	34,535,998	2,212,339	1.18	31,942,609	2,431,454	1.29
Latrobe Steel Co.	1st quar.	7,500,000	.....	...	.....	.....	...
Lone Star Steel Co.	1st quar.	18,868,326	2,484,095	0.70	20,682,706	2,021,876	0.57
Lukens Steel Co.	1st quar.	30,416,889	2,314,442	2.43	20,449,381	1,008,394	1.06
McLouth Steel Corp.	1st quar.	63,258,298	5,826,974	3.24	57,802,749	4,912,028	2.69
National Steel Corp.	1st quar.	219,842,172	17,718,342	2.35	197,659,705	16,504,090	2.20
Phoenix Steel Corp.	1st quar.	17,203,000	123,465	0.11	8,992,000	114,218	0.11
Pittsburgh Coke & Chemical Co.	1st quar.	15,974,000	660,000	0.47	15,595,000	666,000	0.48
Pittsburgh Steel Co.	1st quar.	50,623,846	2,167,577	1.16	51,298,176	1,370,615	0.66
Republic Steel Corp.	1st quar.	375,578,202	28,239,545	1.80	322,657,184	26,844,585	1.71
Sharon Steel Corp.	1st quar.	47,748,160	2,241,477	2.03	34,708,597	590,853	0.54
United States Steel Corp.	1st quar.	1,187,554,615	112,578,752	1.97	1,077,588,292	106,585,303	1.88
Universal-Cyclops Steel Corp.	1st quar.	36,056,000	2,085,994	1.21	.....	2,080,492	1.20
Vanadium Alloys Steel Co.	9 mos.	23,103,778	1,884,994	3.02	16,306,525	1,093,667	1.75
Washington Steel Corp.	1st quar.	.....	737,642	1.15	.....	692,174	1.11
	6 mos.	.....	1,398,492	2.18	.....	1,181,104	1.90
Woodward Iron Co.	1st quar.	.....	1,165,945	0.45	.....	943,744	0.38
Wheeling Steel Corp.	1st quar.	77,122,000	5,547,000	2.43	66,562,000	4,471,000	1.93
Youngstown Sheet and Tube Co.	1st quar.	198,026,404	12,891,248	3.70	184,488,408	11,541,864	3.33

nonferrous castings in February, 1960, totaled 215,345,000 lb, compared with 207,386,000 lb in January, 1960.

△ Labor Dept. consumer price index in March, 1960, rose to 125.7 per cent of the 1947–49 average, 0.10 per cent above February, 1960.

April 27

△ Shareholders of Youngstown Sheet & Tube Co. voted to increase the board of directors to 15 members (from the present 11), and to authorize the board to issue debentures convertible into as many as 600,000 shares of present stock, or more if an adjustment for a split or a stock dividend became necessary—at any time within the next year.

April 28

△ The Bureau of the Census reports that shipments of iron and steel castings in the United States in 1959 totaled 14,644,557 short tons compared with 12,152,882 short tons in 1958.

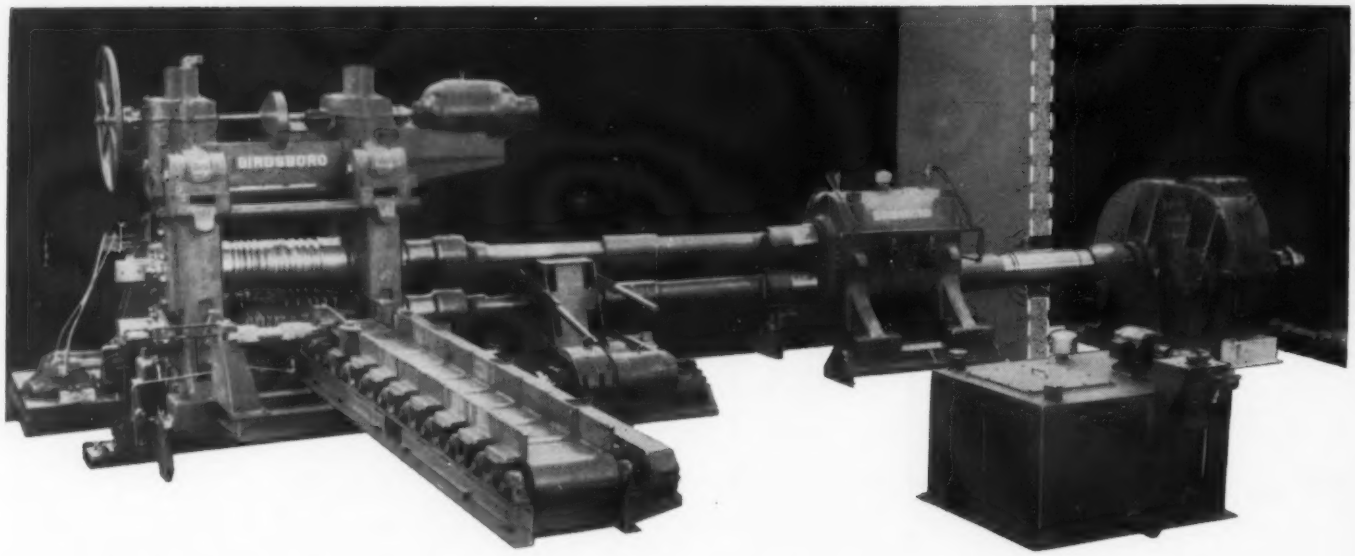
April 29

△ J & L announced that it is among the steel companies working on the development of a lighter tinplate, with a thinner coat of tin for use by the can industry. U. S. Steel Corp. and National Steel Corp. have also announced development work on a similar product.

△ J & L Steel Corp. anticipates that second quarter operations will average 85 per cent of capacity with shipments running about 82.5 per cent.

△ Crow's Nest Pass Coal Co., Vancouver, B. C., stockholders approved sale of all or part of its Pernie, B. C., coal properties to Columbia Iron Mining Co., subsidiary of U. S. Steel Corp., for $10,000,000 for part of the property, with a 4-year option to buy it all for $17,000,000.

△ August Thyssen-Huette A.G. withdrew its application to merge with Phoenix-Rheinrohr A.G., filed late in 1958, because the High Authority wanted to attach "unbearable" strings to its permission, reported a company spokesman.



Dotted lines show schematic location of wall and diaphragm used to seal off room containing argon gas atmosphere. Photograph courtesy of BIRDSBORO STEEL FOUNDRY AND MACHINE CO.

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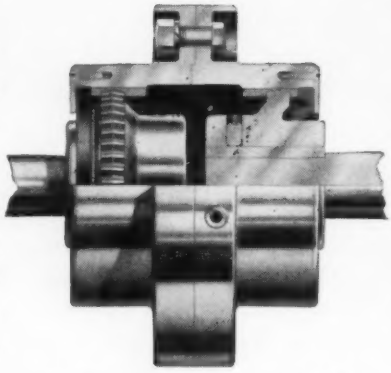
All the power between the speed reducer and pinion stand goes through the coupling to drive the 16"-14" two-high reversing mill.

This is another example of how Ajax Dihedral Couplings answer exacting conditions encountered in modern industry. The broad experience of Ajax Coupling Engineers and Field Representatives is at your disposal for assistance in meeting unusual design and operating requirements.



Cut-a-way view of an AJAX DIHEDRAL COUPLING shows arrangement of hub gears with AJAX patented Dihedral tooth shape.

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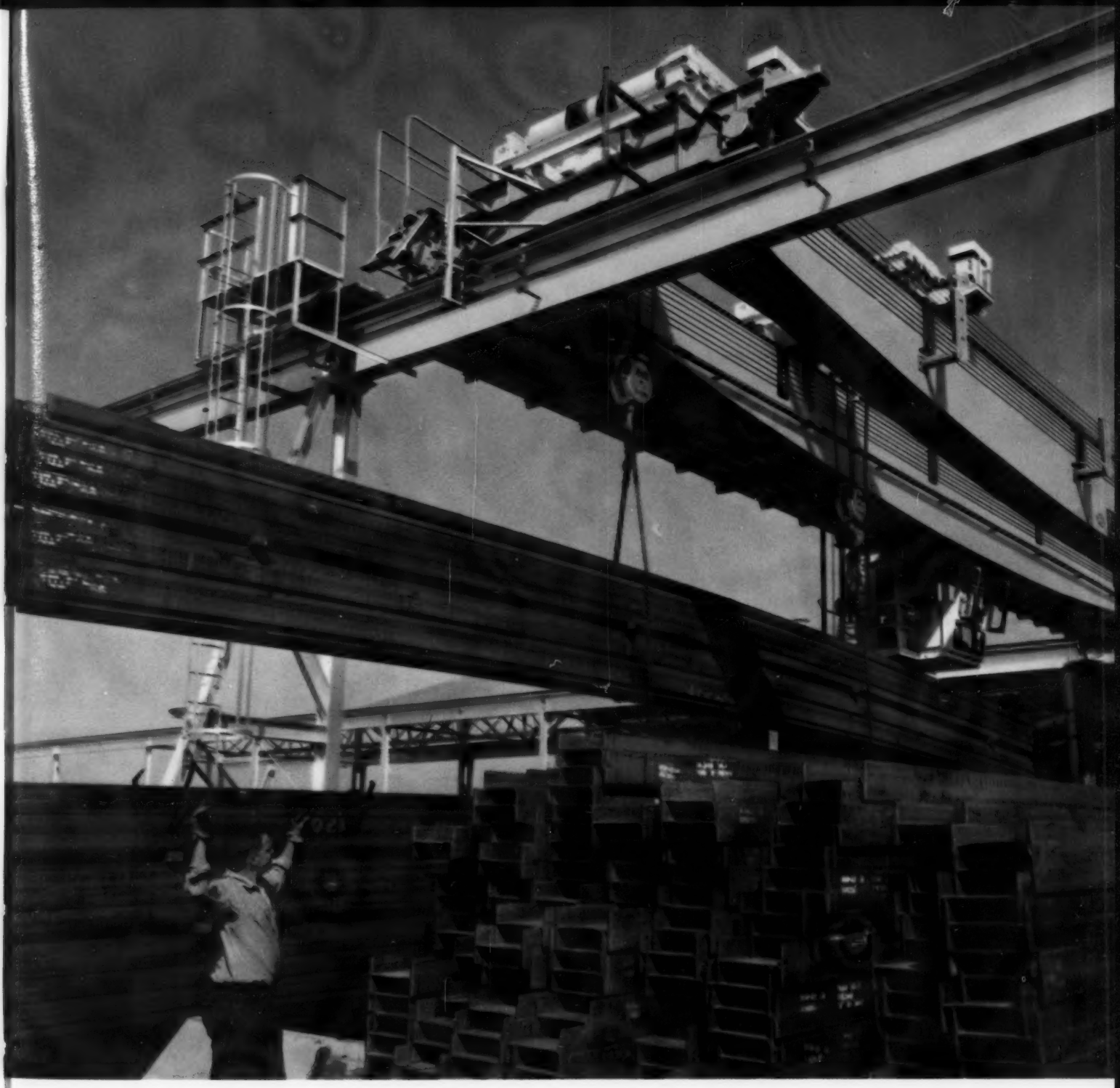

Photo courtesy Pittsburgh-Des Moines Steel Co., Fresno, Calif.

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IN STEEL FABRICATING: This double-trolley crane installation is a good example of the way Harnischfeger engineers design a P&H crane for each particular job. With this arrangement, long, awkward beams can be handled quickly, safely . . . without swinging . . . and with accurate control. In addition, the use of two lighter trolleys permits higher travel speeds, thus combining load stability with fast load handling.

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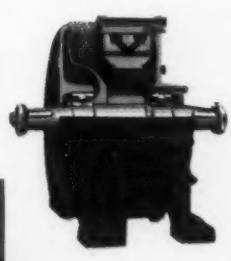
Cutaway view of P&H electric load brake . . . heart of P&H Magnetorque Control . . . which consists of a simple, indestructible rotor and stationary field through which braking forces are exerted electromagnetically.



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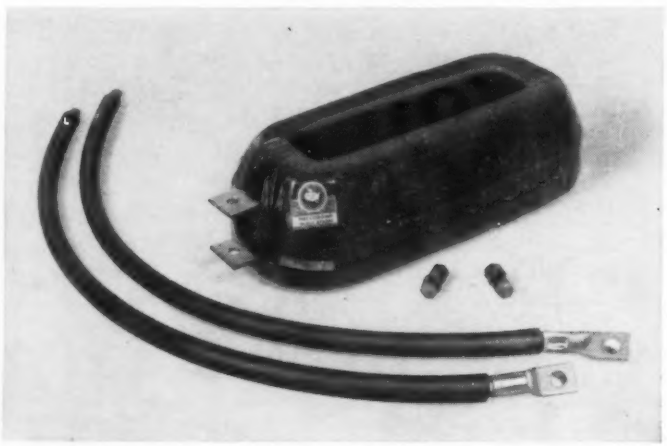

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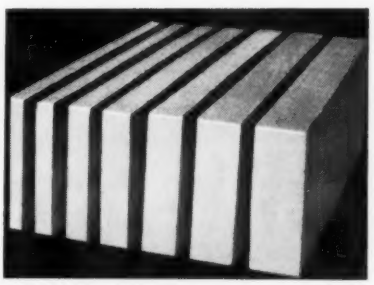


Saves waste. Superex comes in 7 standard thicknesses from 1″ to 4″. Other sizes available on order.

JOHNS-MANVILLE

JOHNS-MANVILLE JM PRODUCTS

Photo courtesy Jones & Laughlin Steel Corporation

Nozzle is key to economy as open-hearth men turn to O_2 to step up furnace output

. . . NBD reports on refractory life, fuel consumption, heat time and lance maintenance as affected by the O_2 nozzle

The injection of pure O_2 into the open hearth is experiencing near-phenomenal growth. The reasons: lower steel costs . . . reductions in heat time . . . fewer man hours per ton of steel . . . marked fuel savings.

At the same time, however, oxygen injection is raising new problems. And because each producer must face these problems in the light of his specific furnace conditions, the net gains to producers vary.

Among the factors calling for special attention are: fume control, refractory life, scheduling and traffic control, and lance maintenance.

Nozzle Is Key To Economy

NBD has been studying the use of O_2 in the open hearth since its early experimental stages. An 80-year-old veteran in supplying steel's bronze and copper needs, NBD has had its national network of technical representatives observing and reporting on the oxygen process.

The most important conclusions derived from these observations are:

OXYGEN DISPERSION—The degree of interaction of oxygen, slag and steel controls heat time and fuel consumption. Slag splash and its effect on refractory life are directly related to the violence of the mixing action.

NOZZLE LIFE—Teeming, transportation, stripping and rolling schedules are dependent on the reliability and service life of the nozzle. Erratic nozzle life, or off-schedule taps due to nozzle failures, can cut seriously into the economic gains possible with O_2 injection.

Maximum dispersion of oxygen, long nozzle life and/or easiest lance-nozzle renewal are the most immediate avenues to the greatest net gains from oxygen injection.

What NBD Is Doing To Insure Top Gains from O_2 Injection

NBD is carrying out the following programs for steel producers:

OXYGEN DISPERSION—On the basis of its studies on lance positioning and lance-nozzle designs, NBD is assisting producers on the determination of most efficient nozzle-port sizes, number of nozzle ports and reflective angles. NBD is also assisting with over-all features of the lance design.

LONGER NOZZLE LIFE—Within this area, NBD study has defined the eight prime causes of erratic nozzle behavior as: (1) manpower failure in lance handling, (2) cooling-water failure, (3) porosity in copper nozzle, (4) failure of welds between copper nozzle and steel-lance piping, (5) limitations of conventional nozzle design, (6) low thermal conductivity of nozzle, (7) oxidation (chamfering) of nozzle ports, and (8) thermal fatigue in nozzle.

The first two of these factors are a prime responsibility of the steel producer. But the next six fall largely within the province of the nozzle supplier. In view of this, NBD has approached nozzle problems from three directions—metallurgy, design and manufacturing—with these results:

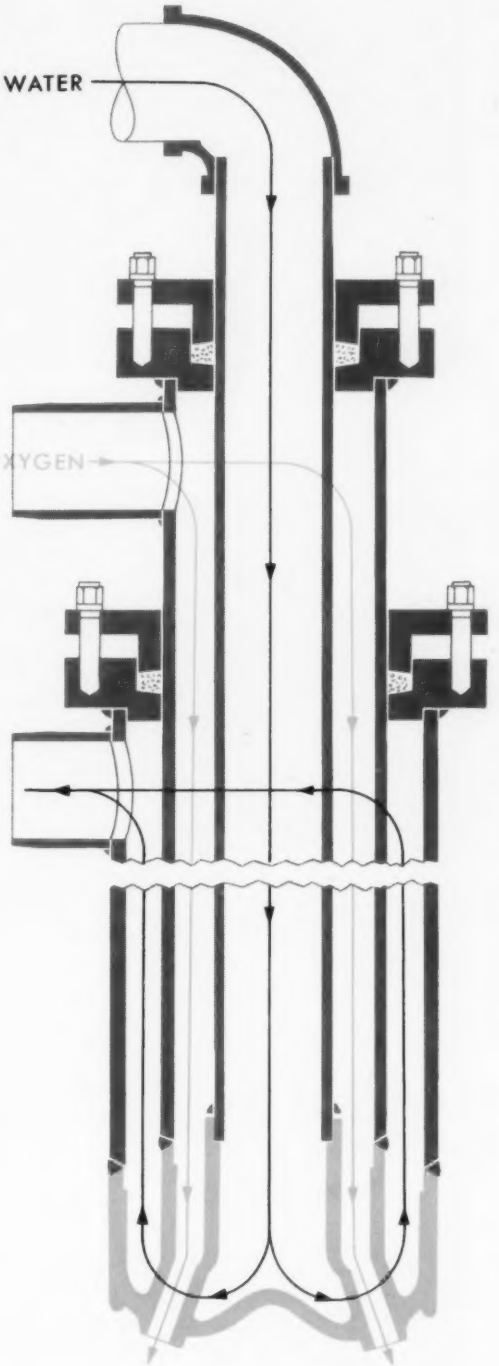
Metallurgy/Manufacturing—Exacting manufacturing controls, specifications and inspection procedures have been established. These assure sound, dense, pressure-tight nozzles of consistently high thermal conductivity. Also good weldability and properly oriented grain size for maximum resistance to thermal fatigue and chamfering.

Design Refinements—NBD design engineers have concentrated on problems of heat transfer, elimination of water and steam trapping and slag plugging of ports. As a result, NBD offers many nozzle and lance refinements. (See drawing at the right.) Among these refinements: internal cooling fins, drip shrouds, special chamfer-minimizing port designs, positive cooling channels.

EASIER LANCE RENEWAL—Welding of copper nozzles to steel lances can be troublesome, so NBD has provided facilities for welding of nozzles to desired lengths of steel lance. Carefully pressure tested and checked for tubing concentricity before shipment, these nozzle-lance assemblies speed renewal in open-hearth maintenance shops. When required, NBD also provides for ceramic coating of nozzles and lances.

If you are now considering conversion to O_2, or are seeking more efficient and economical results from existing installations, NBD is in a position to help.

Benefit from more than seven years' work with the O_2 process! Contact the National Bearing Division, 717-H Grant Bldg., Pittsburgh 19, Pa. Or consult your nearest NBD representative.



U. S. Patent 2,863,656

AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION

717-H Grant Building • Pittsburgh 19, Pennsylvania

...OR IS THERE?

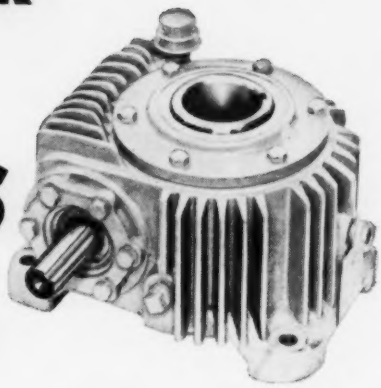
Leukemia now gives its young victims only months of life. But there *is* hope for those with this form of cancer. That hope is research.

Research has already extended the lives of many leukemia patients by months and even years. Research alone can find a way to stop this cancer of the blood-forming tissues once it has mysteriously begun. And every day that a leukemia patient lives allows science one more day to find a cure —or even a new way to extend his life a little longer.

Every year leukemia kills 2,000 children and 10,000 adults, and the incidence is rising. Every year the American Cancer Society allocates more and more money to research specifically related to leukemia. Last year, it allotted nearly $1,000,000 to such research, out of a total research expenditure of about $12,000,000. Much more money is needed this year. The more you contribute, the faster research on leukemia and other forms of cancer will progress. Guard your family! Fight cancer with a checkup and a check! Send your contribution to "Cancer," in care of your local post office.

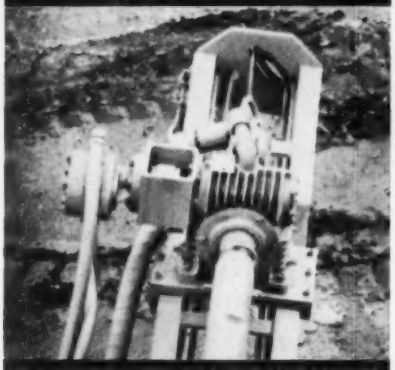
AMERICAN CANCER SOCIETY

CONE-DRIVE WORM GEAR HOLLOW SHAFT SPEED REDUCERS

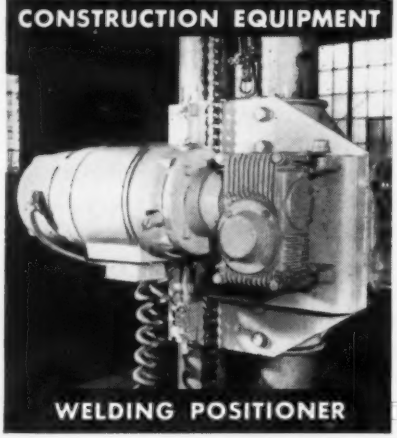


provide greater flexibility in the design of your equipment

MIXING MACHINE



CONSTRUCTION EQUIPMENT



WELDING POSITIONER

Standard Cone-Drive hollow shaft speed reducers are available in four basic sizes (2, 2½, 3 and 3½ inch center distance units) to accommodate loads from fractional to 13 horsepower. They are built around the double-enveloping worm gear design and carry the same high ratings as standard Cone-Drive speed reducers.

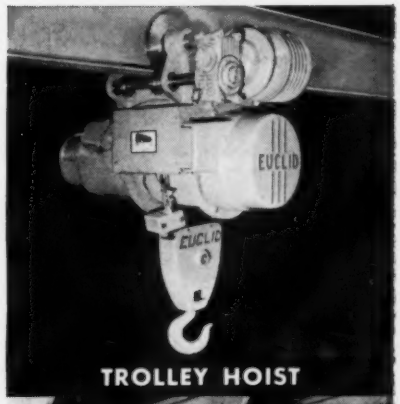
You, as a designer, will be particularly interested in the versatility of application and space savings made possible by the right angle design between input and output shafts.

The reducer is mounted directly on the driven shaft and requires only a simple bracket or torque arm to prevent it from rotating about the driven shaft.

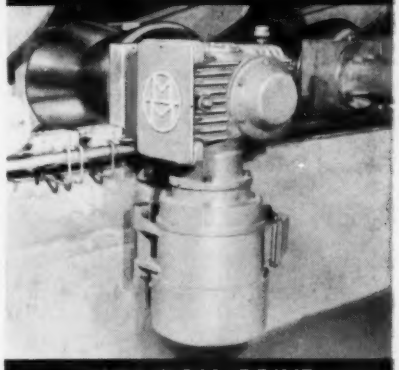
Construction is rugged enough to permit floor or wall mounting of Cone-Drive hollow shaft reducers and "hanging" the driven shaft on it (in certain applications), eliminating pillow blocks or bearings. Larger-than-necessary taper roller bearings and heavy-duty castings make this possible.

If a motorized reducer is desired, a simple, standard bell housing can be furnished for NEMA C-type face motors. The need for expensive couplings is eliminated since a tang-type drive sleeve and suitably machined worms are provided. When a hollow-shaft speed reducer and face-mounted motor are combined, no bed plate or mounting arrangement is required. Pulleys, belts, sheaves, etc., that might be troublesome or difficult to install are also eliminated.

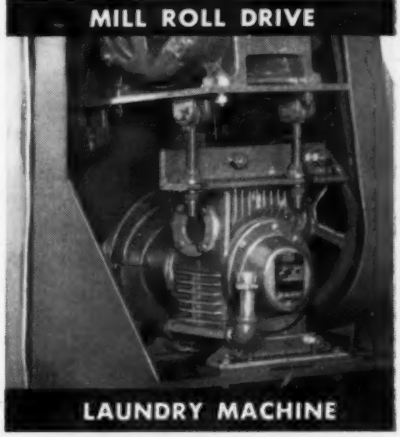
Ask for Bulletin CD-218.



TROLLEY HOIST



MILL ROLL DRIVE



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PLANTS AT LIMA AND SPRINGFIELD, OHIO... *Virtually at the center of the steel industry*

Industry News...

EXPANSION PLAN BEGINS AT ALLEGHENY LUDLUM

△ A new program of substantial expansion and modernization of Allegheny Ludlum Steel Corp.'s plant facilities was recently revealed.

The new program, estimated to require an expenditure of $40,000,000 over the next three years, is under way at principal locations of the corporation's operations.

The largest project is a new steel rolling and processing mill being built on a 90-acre site at Bagdad, Pa., across the Kiskiminetas River from Allegheny Ludlum's West Leechburg Works. The Bagdad facility, with an initial 160,000 sq ft of work space, will process high-grade, grain-oriented silicon electric strip steel. A large normalizing line, a major cold-rolling mill, equipment for slitting and shipping, and auxiliary equipment for processing electric strip steel will be installed.

At the same time, the additional manufacturing capacity at Bagdad will free a portion of the facilities at the West Leechburg Works for processing stainless steel strip.

The entire proposed three-year, $40,000,000 program of expansion and modernization will improve manufacturing efficiency, will help lower costs and will increase mill capacity. The bulk of the funds required for the new capital improvements program will come from money already available and from retained earnings and accruals for depreciation.

Allegheny Ludlum's new capital spending program will also include improvements at other plants of the company. Noteworthy among these will be the installation later this year of the world's largest vacuum-melting furnace, of the consumable electrode type, at the Watervliet, N. Y., Works. Also included are "pilot plant" versions of mill processing equipment being installed in the company's new centralized research center at Brackenridge, Pa. This center, which will be completed in 1960, further strengthens an already intensive research effort aimed at developing more useful metals, improving the quality of existing products and the efficiency of production processes.

SEMI-AUTOMATIC WELDING BLAST FURNACE GIRDERS

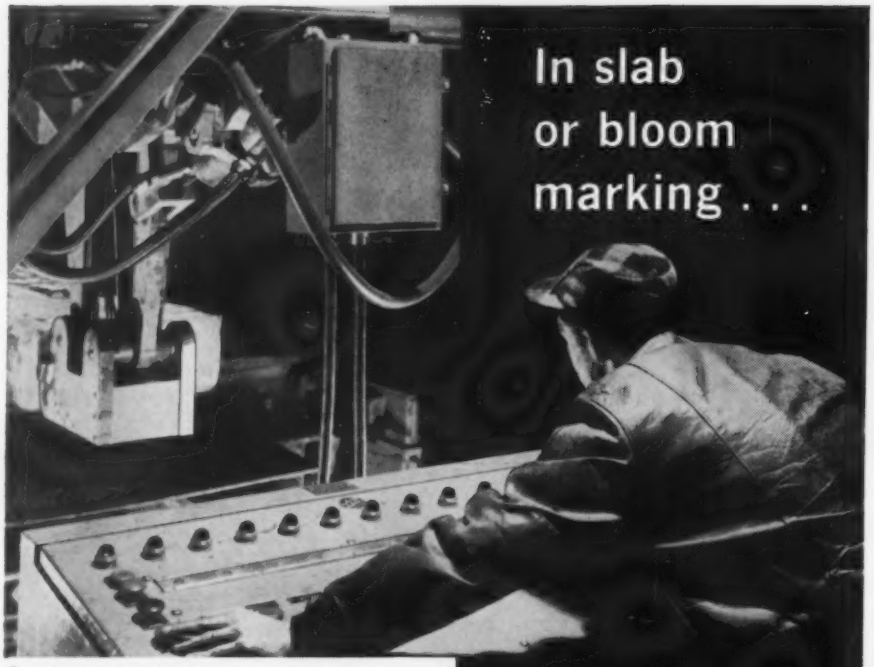
Operator with a semi-automatic submerged arc welder deposits metal at a rate in excess of 10 lb per hour, on this blast furnace ridge girder segment. Each segment of the ridge girder has a curbed plate like a segment of a cylinder. This plate is stiffened by two 2 in. thick plates that fit together in a "V" shape and fit snugly against the plate. There are three heavy joints on each segment. One of them is an open corner weld where the two plates come together. The other two join the "V" stiffener to the curved plate. The entire segment is tack welded together with low hydrogen electrodes. The operator, using a manually operated semi-automatic welder, first makes one of the welds joining the stiffener to the plate. Then, he turns the plate over and puts in the other similar weld. Finally, he positions the segment, so that the open corner joint is in the flat position and completes this weld. To keep the plane of the weld in the flat position, he hooks a jib crane on one end of the segment. As he works his way around the curved surface, he lowers the crane supported end, so that the joint is always flat.

NEW PROCESS COMBATS ACID STREAM POLLUTION

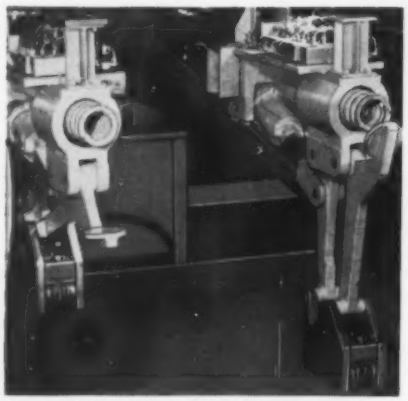
△ Waste acid solutions used to pickle or clean steel may be reclaimed using a new process announced by Ionics, Inc., of Cambridge, Mass.

The process will not only eliminate the problem of water pollution from this source, but it also appears likely to save money for the users, according to Ionics. Dissolved iron usually thrown away is recovered as well as the spent acid.

Executive vice president, Dr. Walter Juda, provided cost figures showing that "... A typical steel plant now in daily operation and requiring about 50 tons per day of sulphuric acid for steel pickling would eliminate about $500,000 per year for acid and waste disposal charges. Crediting the electrolytic iron recovered at only scrap value, costs for a reprocessing plant, including 20 per cent write-off per year plus all operating costs, would probably be significantly less," he said.



Operator presses button to actuate stamping cycle or change characters—installed at a transfer table.



Twin units for automatic consecutive numbering of 2½" bar billets—for installation along edge of cooling bed.

Double-headed Slab Marker with 18 stamping wheels, photographed during testing—for installation over a roller line.

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HAS THE
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14 UNITS IN SERVICE . . . MORE ON ORDER

Under constant development for more than 12 years, Mecco Safety Slab Markers are the industry's most advanced—*the most thoroughly service-proved*, by a margin of hundreds of thousands of tons.

We'll gladly consult with you on any phase of steel industry marking. *May we send technical bulletins on Slab Markers?*

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"In spite of the probable profit to be made, a break-even cost would be most welcome just to eliminate the water pollution problem," he emphasized.

Total capital investment required for the typical plant referenced by Dr. Juda was quoted as about $700,000. The over-all picture shows a potential saving of about $20,000,000 in the U. S. and an equal amount elsewhere in the western world, Dr. Juda stated.

WILL APPLY COMPUTER TO BAILEY SYSTEMS

△ Bailey Meter Co., has concluded an agreement to apply the Packard Bell Computer Corp.'s new medium-scale, "second generation" computer as a component of Bailey systems for power plants and industrial processes. This solid-state digital computer has a large expandable memory and computing speeds in the microseconds.

The computer will be integrated into Bailey Metrotype digital systems and combined with Bailey instruments, controls, and analog computers to provide compact closed loop control and information systems. This arrangement will enable plants to apply data processing and computer control systems step-by-step or in any combination as their use becomes economically justifiable. Engineering of the integrated systems is scheduled for completion so that marketing will start late in 1960.

The resulting integrated systems will be applied to the control of power and process operations which require extensive real-time calculations to achieve optimum performance.

BIRDSBORO TO FURNISH NEW TUBE SIZING MILL

△ Birdsboro Corp., has received a contract to engineer and build a three-stand tube sizing mill for the South Chicago Works of Republic Steel Corp.

The center stand of the mill, now under construction, will be a vertical stand featuring quick and easy change. The entire overhead pinion housing for this stand will swing 90 degrees, leaving the mill housing open for convenient re-

12 B&W IFB lined single stack annealing covers in use in the strip annealing department of Weirton Steel Company, a division of National Steel Corporation, at Weirton, West Virginia.

WEIRTON STEEL COMPANY uses lightweight B&W Insulating Firebrick for single stack annealing covers.

These 12 covers, lined with B&W K-20 Insulating Firebrick, have been in service more than two years in the annealing of low and high carbon strip from Weirton's 54″ strip mill. Identical in construction, the covers are over 17 feet from base to skew and over 10 feet in diameter. The domes are of 9″ K-20 IFB construction.

The K-20 is one of B&W's *lightweight* Insulating Firebrick. In fact, B&W K-20 IFB are at least a third of a pound lighter than other 2000 F insulating firebrick. This means savings in the overall weight of portable covers. Additional savings in fuel consumption and cycle time are possible because lightweight B&W IFB store and conduct less heat. Heat is kept in the furnace, not in the lining.

This application points out advantages of light weight in insulating firebrick constructions. And B&W makes the *lightest* weight insulating firebrick. Consult your B&W Refractories Representative for information on how you can profit with lightweight B&W IFB.

Bulletin R-2-H available on request.

B&W

THE BABCOCK & WILCOX COMPANY

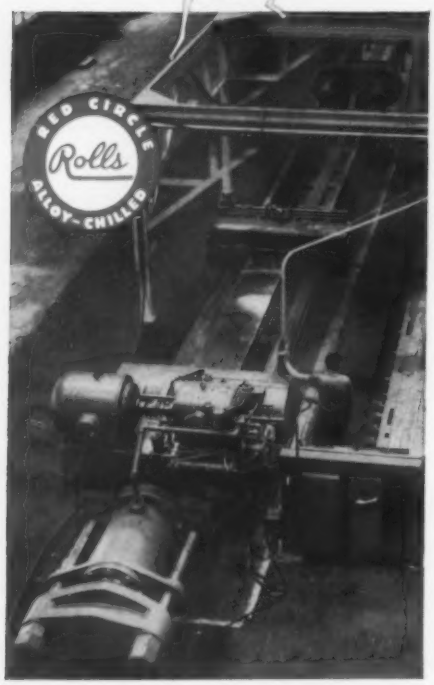
REFRACTORIES DIVISION

R-617

B&W Firebrick, Insulating Firebrick, and Refractory Castables, Plastics, Ramming Mixes, Mortars, and Ceramic Fiber.

Hyde Park

STRETCHER LEVELLERS



Hyde Park Levellers have a complete range of stretching capacities from 150 to 1250 tons—for levelling ferrous and non-ferrous sheets in sizes up to 120 inches wide by 500 inches long.

Adaptable for automatic cycling.

Pneumatically or hydraulically operated wedge or toggle type jaws.

Hyde Park

FOUNDRY AND MACHINE CO.

HYDE PARK
Westmoreland County, Penna.

Rolls
Rolling Mill Equipment
Gray Iron Castings

moval and replacement. Placement of the pinion stand over the roll stand eliminates the need for a pit beneath the roll stand and keeps scale and roll coolant from falling onto the pinion housing. The two end stands in this mill will be horizontal stands.

All stands and drives will be raised and lowered vertically by two motor driven wedge adjustments. The bottoms of all tubes passing through the mill will be maintained at a fixed elevation.

No special tools will be needed to change the vertical and horizontal mill housings, all three of which are interchangeable. Housings are designed for fast removal by means of a remotely controlled hydraulic system that rotates the vertical drive and actuates the spindle pull backs, housing clamps and drive clamps.

A single 500 hp constant speed a-c motor will drive all three stands on the mill.

The special equipment, will warm roll P-110 tubing, having yield strength when cold of up to 170,000 psi. It will handle tubes ranging between $4\frac{1}{2}$ and $10\frac{3}{4}$ in. diam.

SENDZIMIR MILL TO ROLL THIN TINPLATE

△ A nonreversing Sendzimir mill, designed to roll 40-in. wide low carbon steel to tinplate gages, will soon be installed at the Granite City Steel Co. Making tinplate from previously cold rolled material is a new application for a Sendzimir mill.

Complete electrical equipment for the mill drive will be furnished by Allis-Chalmers Manufacturing Co. The mill will be driven by a 4000-hp, double armature (2 × 2000-hp, 600-volt) 500/750-rpm drive motor. Entry or pay-off reel is to be powered by a 1200-hp, double armature (2 × 600-hp, 300-volt) 300/1080-rpm drag generator while the winding reel is to have a 1200-hp double armature (2 × 600-hp, 375-volt) 185/835-rpm motor. Included are automatic gage control on the mill and the new design load regulating tensiometers using pressductors.

Supporting the mill equipment is a synchronous motor-generator set with two 1600-kw generators, one 1000-kw generator, provision

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Write for technical data and catalogs on the above and many other R-S Furnaces to . . .

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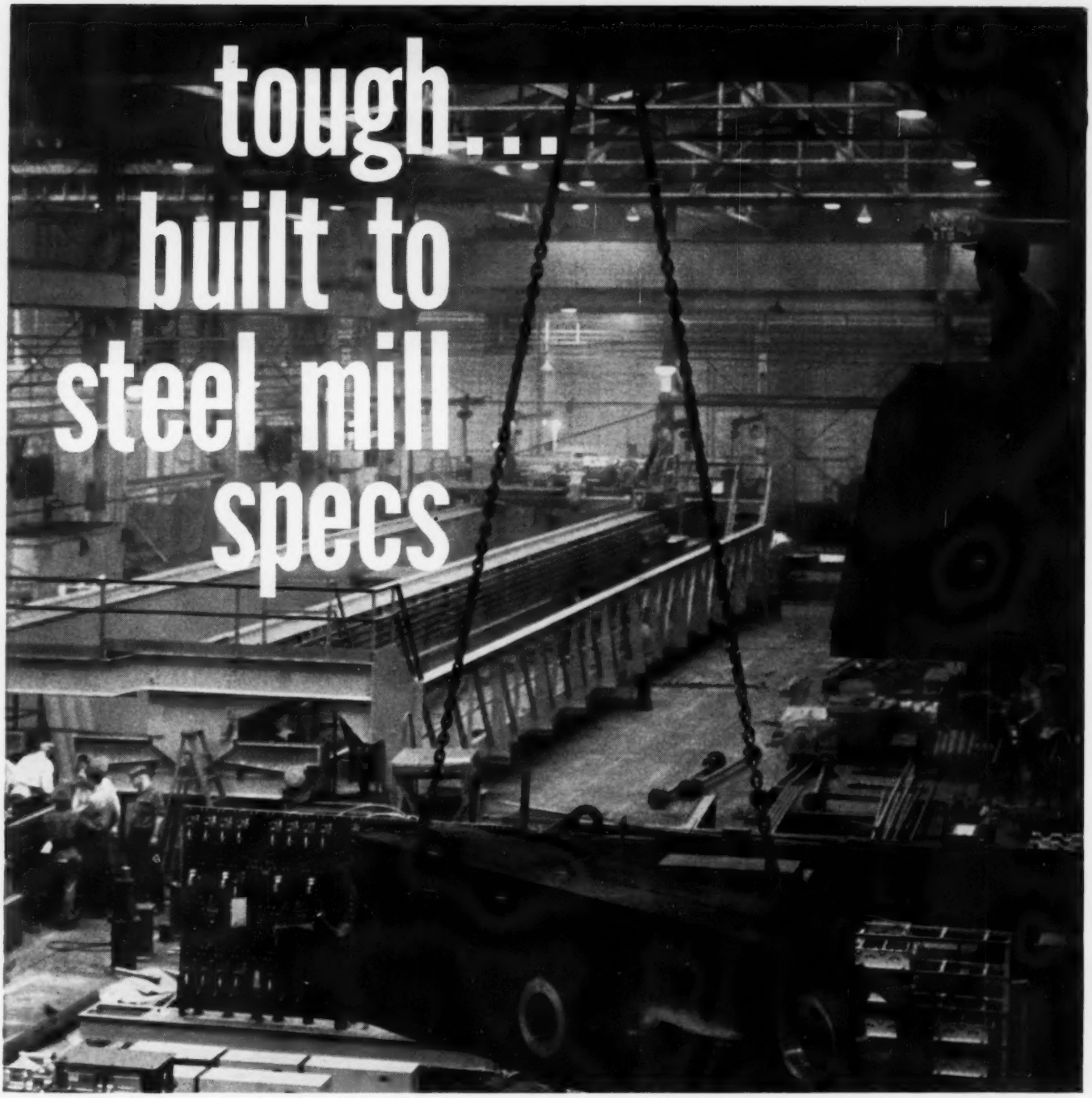
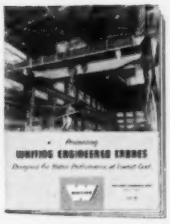


This tough 30-ton Whiting Tiger Crane with a 125′ span is thoroughly checked out on the assembly floor . . . then it's off to rugged, round-the-clock steel mill service. Whiting cranes for mill service easily meet the highest set of standards in all industry, A.I.S.E. specs, or are built to exacting customer requirements. And important Whiting extras like oil bath lubrication, herringbone gears, and long life antifriction bearings assure added years of efficient, dependable maintenance-free operation.

Whiting is your answer to every overhead handling problem. Write for the facts on "Whiting-Engineered Cranes," bulletin 80. *Whiting Corporation, 15655 Lathrop Avenue, Harvey, Illinois.*



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WHITING

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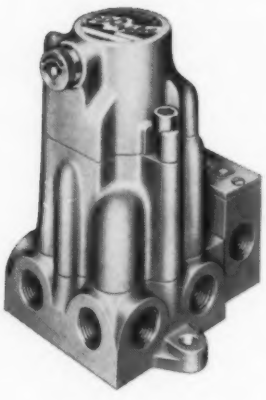
Compare what the **PDQ WILL DO...**
Compare the **PDQ PRICE...**
With any other air valve...



a ½" valve that will do a ¾" valve job at a ⅜" valve price

- ☑ Accessibility
- ☑ Simplicity
- ☑ Speed and Capacity
- ☑ Price and Quality

What will the PDQ do? It will do a ¾" valve job. It has faster response time and greater capacity than valves twice its size and four times its weight. To repack you simply replace 2 self-contained units in less than a minute. You can change valves on the line in less than 30 seconds.

Will the PDQ last? The PDQ has a short stroke, and a light but rugged aluminum construction with built-in wear compensation. Anticipated valve life is conservatively estimated at 35 million cycles . . . on most applications this is **years** of trouble-free service. Coil (properly applied) is unconditionally guaranteed for the life of the valve.

How about the price? The PDQ is a ½" valve at a ⅜" valve price. Write us today.

A. V. Ney

A. V. Ney, Sales Manager

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HUNT HVC ***Quick-As-Wink*** AIR & HYDRAULIC CONTROL VALVES

for installing a 1000-kw, 750-volt existing generator purchased previously, and a 5500-hp synchronous drive motor.

Main drive control includes 400-cycle mag-amp control of the main generator fields and 60-cycle mag-amps for the motor fields, using all static excitation for the mill. Furnished also are the 6900-volt switchgear, updraft ventilating equipment and a-c auxiliary motors and controls.

Essentially, this is how the process will work: The four-stand cold mill, which was revamped by Allis-Chalmers two years ago, produces strip at 0.015 in. thick at 3500 fpm. To get additional cold mill tonnages, the Sendzimir mill will take the 0.015-in. thick full hard material from the tandem cold mill and reduce it one pass to the 0.008-in. tinplate thickness.

TO MARKET STAINLESS STEEL IN COLORS

△ Allegheny Ludlum Steel Corp., after several years of research and development, is producing stainless steel in colors. The announcement was made by W. B. Pierce, vice president in charge of sales for the company.

The colored stainless steel will first be offered in shades of brown and black, which have already been thoroughly tested, Mr. Pierce said. Soon afterwards, the metal will be available in a wide range of colors as the development work continues. A number of additional colors are now being intensively field tested, including various shades of blue, green, red and gray.

The first commercial uses of colored stainless from Allegheny Ludlum will be in architectural panels for curtain-wall buildings.

"The development of a new, economical method for coating stainless steel enables us to offer the metal in a variety of permanent colors that will be pleasing and useful to architects, builders and manufacturers," Mr. Pierce said. He emphasized that stainless steel, in any of its variety of natural finishes, has proved to be one of the most useful architectural metals, noted particularly for its beauty, strength, corrosion resistance and ease of maintenance.

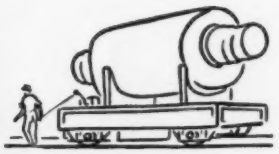
The new colored stainless steel will create wide interest among manufacturers of consumer products as well, Mr. Pierce said. Building hardware and decorative materials, kitchen and laundry appliances, auto trim and wheel covers, serving trays, coffee makers, refrigerator doors and trim, acoustical tiles, furniture and a variety of other products will be made of the new material, Allegheny Ludlum predicted.

Color in stainless steel is achieved through the application of a chromate-base, coating similar to that used on the inner lining of metal containers, Allegheny Ludlum revealed. The coating is applied by spraying, brushing or rolling. After that is done, the coated stainless is "cured" at temperatures of about 350 F.

Different colors are obtained through the addition of various pigments to the basic coating material. The result is an attractive, evenly colored surface which is smart, durable, abrasion-resistant and corrosion-resistant.

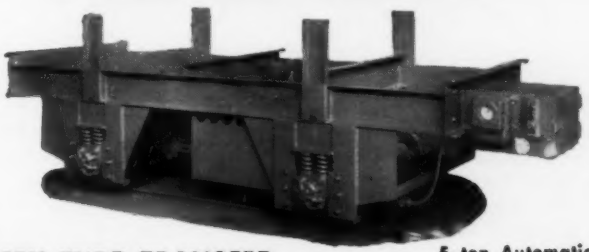
The new colored stainless steel announced by Allegheny Ludlum uses a coating material supplied by

HANDLES THE BIG LOADS WITH BIG SAVINGS



100-ton Battery Operated

ATLAS *Safety Type* TRANSFERS



5-ton Automatic Controlled

ATLAS SAFETY-TYPE TRANSFER CARS can be provided in almost any capacity for storage battery, diesel or gas-electric, or cable reel service.

They are safe because there is only one control lever, and the car moves only when the operator holds the lever.

Request "Walk-Along" Bulletin 1283.

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ENGINEERS AND MANUFACTURERS SINCE 1896

the Heintz Division of the Kelsey-Hayes Co. and designated by Heintz as "HINAC." Successful application of this coating material to stainless steel sheets was achieved through joint development work by scientists and technical men at Allegheny Ludlum and Heintz.

Allegheny Ludlum revealed that this new coating process is simpler, more economical and more effective than previously announced methods of making black or gray coated stainless steel. The new process requires no unusual pretreating, no primer undercoat and no baking at extremely high temperatures to achieve color adherence. Other advantages of the new coating are: greater uniformity of color, good surface adherence and abrasion resistance.

MORGAN ENGINEERING CO. FORMS NEW SUBSIDIARY

△ Formation of a new corporation, Crane and Mill Sales, Inc.—a sales subsidiary of the Morgan Engineering Co.—has been announced.

Headquartered at Pittsburgh, Pa., the new firm will market Morgan's complete line of heavy duty mill cranes, mills and other allied steel making equipment. The firm will also handle the complete line of industrial type cranes and hoists manufactured by Euclid Crane and Hoist Co. Distribution of the Euclid line will be in the same Pittsburgh district but on a specific account basis, covering the steel mills and closely related industries.

Thomas E. Hughes has been appointed vice-president and general manager of the new organization. He resigned as manager of Morgan's Pittsburgh district to accept the new post.

ALIQUIPPA WORKS ADDS NEW TINNING LINE

△ Construction on a new halogen type electrolytic tinning line has been started at the Aliquippa Works of Jones & Laughlin Steel Corp., it was announced today by A. C. Keller, works manager.

The new facility will equip J & L's Tinplate Department with the most modern lines for the electrolytic plating of strip steel. The Tinplate Department also operates two other modern halogen type electrolytic tinning lines. The new line is expected to go into operation late this year.

The new electrolytic tin line will replace an older alkaline tinning line which has been in service since 1943.

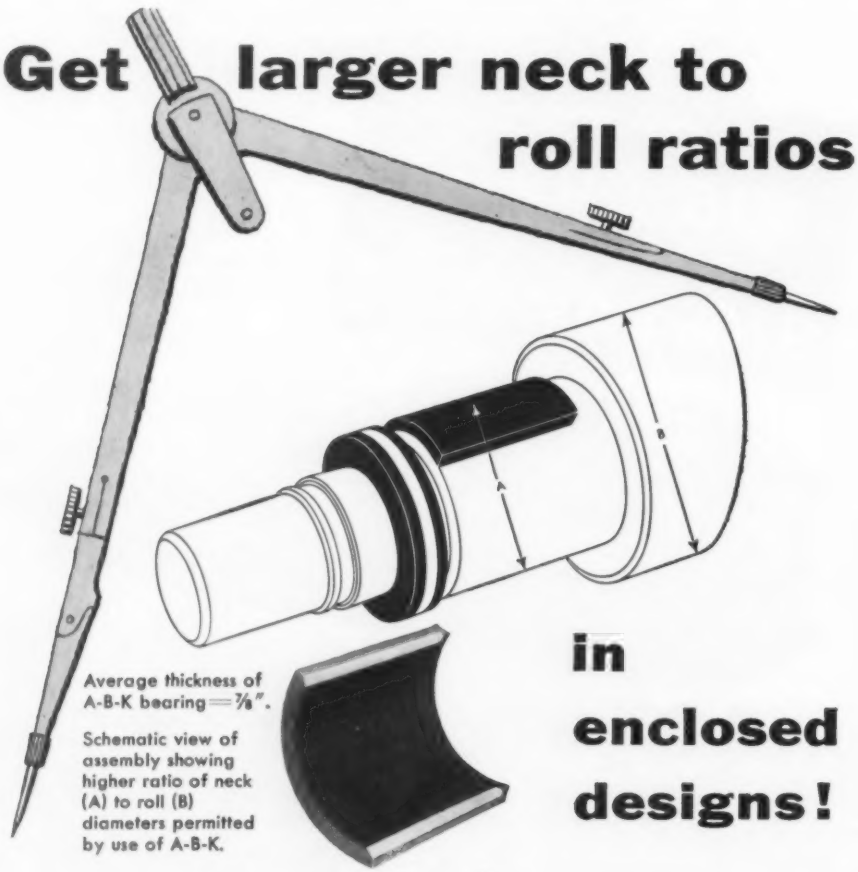
The new line will incorporate the most modern features in the manufacture of tinplate, Mr. Keller said.

"One of the features of the new line will be a looping tower at the entry end, permitting full speed operation during the welding cycle," he said.

The new line also will feature a high-frequency brightening process which brightens the product through the use of 2400 kw of electricity. This improvement also has been included in J&L's other electrolytic lines.

Modern silicon rectifiers of the latest engineering design will be installed in the new line. These will replace copper oxide rectifiers which were used in older lines in the

Get larger neck to roll ratios in enclosed designs!



Average thickness of A-B-K bearing = 7/8".

Schematic view of assembly showing higher ratio of neck (A) to roll (B) diameters permitted by use of A-B-K.

use A-B-K* bearings

No need to sacrifice roll neck diameters to keep down size and cost of bearing assemblies and housings. A-B-K bearings save space, permit larger, stronger roll necks—with cheaper, lighter weight parts. A-B-K laminated phenolic bearings have ability to absorb and cushion heavier impacts, and often outwear metal, many times. Grease and oil can be used for lubrication but water, alone, is often the answer. Ask our engineers for specific recommendations.

- Wear longer
- Won't score or heat check
- Light in weight
- Cut lubricant costs
- Save power

A-B-K
LAMINATED
PHENOLIC BEARINGS

*A registered trade-mark of American Brake Shoe Company in the United States and of Joseph Robb & Company, Limited, in Canada.

AMERICAN Brake Shoe COMPANY
AMERICAN BRAKEBLOK DIVISION
P. O. BOX 21, BIRMINGHAM, MICHIGAN

BIG—BUT TAKEN IN STRIDE BY B-L-H's FABRICATING TEAM

Fabricating jobs like the nuclear reactor being installed for the AEC at Hallam, Nebr., are no strangers to B-L-H. We have handled such tasks many times.

To get an idea of what's involved, note these facts about the Hallam reactor:

Reactor vessel

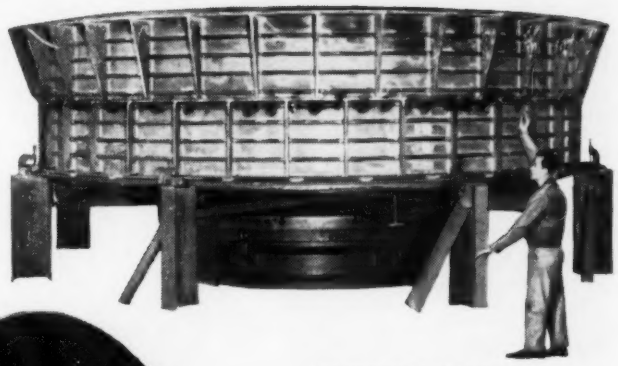
- 19 ft. in diameter, 33 ft. high, welded of Type 304 stainless steel
- Metal thickness range from ¾ to 2 in.
- All material subject to ultrasonic inspection; all welds inspected radiographically, also with dye penetrant and helium leak detection equipment

Reactor containment vessel

- 21 ft. in diameter, 36 ft. high
- Bottom head fabricated of carbon-silicon steel, main barrel section of chromium molybdenum steel
- All welds radiographed, bottom head section stress relieved

Keep in mind, too, the fact that for parts as large as these —and with the limited amount of machining—the tolerances call for highest accuracy in fabrication.

Handling big fabricating jobs economically and efficiently is our stock in trade. So take advantage of our exceptional experience and competence. Consult us about your next project and write now for a copy of our illustrated Weldment Bulletin 7001.



Loading face shield shell of Hallam reactor being check-fitted to upper cavity liner

X-ray inspection at B-L-H's Industrial Equipment Division of weld joints in lower shell course of containment vessel for the Hallam, Nebr., nuclear reactor designed by Atomics International

BALDWIN · LIMA · HAMILTON

Industrial Equipment Division · Philadelphia 42, Pa.

4 High Non-Reversing

COLD MILL

The Pittsburgh 8½" x 24" x 20" Intermediate Cold Mill illustrated is now in continuous production in the Chicago area with a rated capacity of 18,000,000 lbs. per year.

It can be used for reduction of either non-ferrous or ferrous alloys at your required rolling speeds.

This mill is typical of the modern equipment for the rolling mill industry now being designed and produced by Pittsburgh Engineering and Machine Division for installation in the United States and other countries.

Your inquiries are invited.

Electric and open hearth steel castings from 1 lb. to 100 tons

by

PITTSBURGH

ENGINEERING & MACHINE DIVISION

HEAVY MACHINING FACILITIES

Our plant is equipped with a superior complement of well diversified machine tools that are available on a continuing basis for economical machining of heavy castings or the manufacture of auxiliary rolling mill equipment, such as heavy mill tables, furnace pushers, slab depilers, downcoilers, ingot buggies, slab transfers, etc.

Pittsburgh Steel Foundry Co.

TEXTRON, INC.

564 FORBES AVENUE

PITTSBURGH 19, PA.

PLANTS AT GLASSPORT AND McKEESPORT, PENNSYLVANIA

plating of the pure tin to the strip steel.

The line will have another innovation—horizontal pickling on two different levels to conserve floor space. The new line will be 275 ft long while the No. 3 electrolytic tinning line, a modern unit similar except for the horizontal pickling feature, is 456 ft long.

The new line will handle coils of strip steel in widths ranging from 18 in. through 37 in., and up to 80 in. in outside diameter.

Much of the new line will be installed while the older line is in operation to eliminate loss of production, Mr. Keller said.

In the operation of the new electrolytic tinning line, coils of strip steel are welded together to form a continuous length which is then cleaned, pickled, scrubbed and electrolytically coated with pure tin. The line will be capable of differential coating—putting a heavier coat of tin on one side of the tinplate than on the other.

The tinplate is then rinsed and brightened with the high-frequency brightener. Equipment will continuously inspect for gage, top and bottom tin coating and pin holes. Lineal footage is continuously recorded. After plating, the tinplate is electrostatically oiled, then coiled on tension-type reels.

SPARROWS POINT TO BOOST ANNUAL CAPACITY

△ Plans to increase the annual production capacity of Bethlehem Steel Co.'s Sparrows Point, Md., plant to 9,000,000 ingot tons within the next two years were disclosed by C. T. Stott, general manager. The proposed increase of approximately 800,000 tons represents a hike of nearly 10 per cent.

Although Mr. Stott declined to extimate the cost of the expansion, he said that it was included in the $197,000,000, which A. B. Homer, Bethlehem president, recently informed stockholders had been authorized for the company's current plant expansion and improvement program.

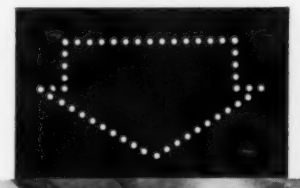
Key to the increased ingot capacity, Mr. Stott explained, is the plan to equip all furnaces in the new No. 4 open hearth shop for the use of oxygen. This shop, with its seven 375-ton furnaces, was completed in 1958, and with the new oxygen equipment will provide most of the increased tonnage.

Details of this expansion program may be found in the article on page 159 of this issue.

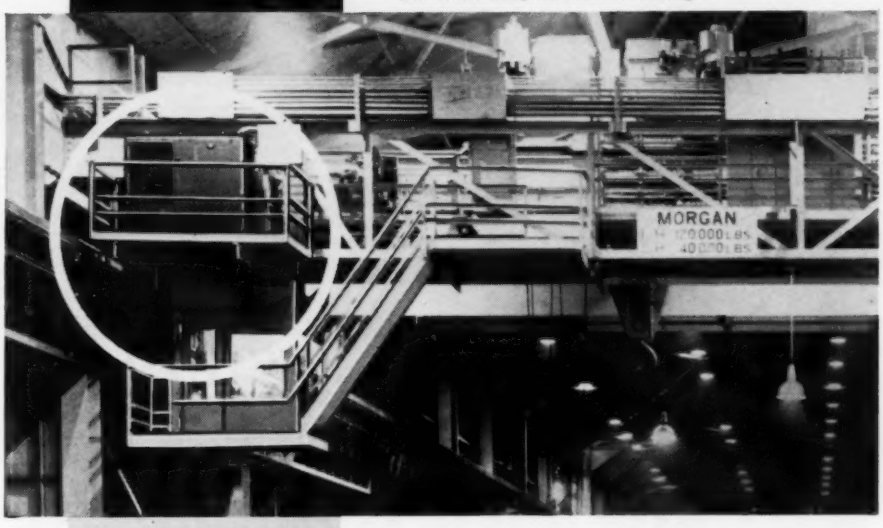
Meetings

△ A national symposium on "Temperature—Its Measurement and Control in Science and Industry" will be held in Columbus, Ohio, March 27–31, 1961, jointly sponsored by the American Institute of Physics, the Instrument Society of America and the National Bureau of Standards, with other societies and governmental agencies cooperating.

This will be the first conference of this breadth and scope since the New York conference on the same subject in 1939. The symposium will be aimed at the fundamentals of temperature measurement to complement the material in the 1939 volume and will provide an authoritative blending of papers on the meaning of the temperature concept as well as analytical theory.



Model 527 AC-7.5 Lintern Aire-Rectifier installed on a Morgan crane operating in the annealing department of the tin mill plant at the Weirton Steel Division of the National Steel Corporation, Weirton, West Virginia. Note condenser on platform attached to footwalk. It is connected by refrigerant lines to the Cooling Unit in the cab, mounted on ceiling.



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CAPITAL EQUIPMENT

by **LINTERN** AIR CONDITIONING

By air conditioning crane cabs and pulpits, plants are making the most of profit opportunities — achieving full use of costly equipment and getting the most return on capital investment.

Lintern Aire-Rectifiers are made in a range to meet all conditions — from 90°-230° F. More than one thousand are in daily service on practically every type of crane and pulpit operation in steel, aluminum, copper, and other industrial plants, wherever excessive heat, dust, gas and fume conditions are prevalent.

ASK FOR BULLETIN AC-573.

Larco, inc.
DISTRIBUTOR OF LINTERN CORPORATION PRODUCTS
ROUTE 20, EAST • PAINESVILLE, OHIO

Operation: Descaling

(One of a series)

Pangborn Rotoblast proves itself again...and again...and again...and again!

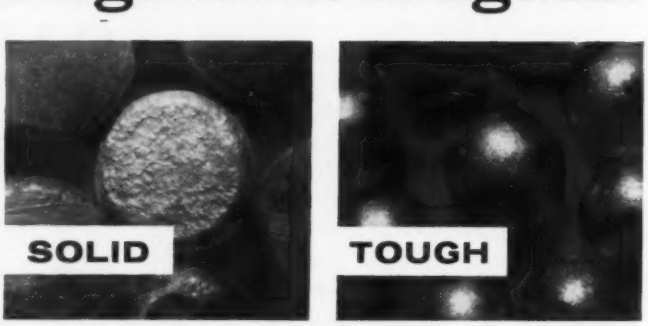
Bustin Steel Products, Dover, N. J.—In descaling steel bars, Pangborn Rotoblast saves $75 a day over pickling *plus* the cost of degreasing.

Kelsey-Hayes Co., McKeesport, Pa.—Pangborn Rotoblast descales steel sheets at 30% to 40% below cost of previous pickling method.

Southern Sales and Transportation Co., Houston—Pangborn Rotoblast enables this company to save by buying hot rolled stock instead of cold rolled or pickled and oiled stock.

Midwest Auto Parts Manufacturer—Pangborn Rotoblast saves this firm $1 a ton, or $10,000 per month in descaling costs.

Above are just some of the successful Pangborn Rotoblast installations. If *your* problem has to do with descaling, talk to your Pangborn man or write PANGBORN CORPORATION, 4400 Pangborn Blvd., Hagerstown, Md. *Manufacturers of Blast Cleaning, Vibratory, Dust Control Equipment—Rotoblast® Steel Shot and Grit.*®



Rotoblast Steel Shot and Grit prove their value, too . . .

. . . made by exclusive processes to produce a *solid, tough* abrasive. Used in today's blast cleaning equipment, Rotoblast Steel Shot and Grit hold up for many more passes than ordinary abrasive, reducing replacement and cleaning costs.

Pangborn
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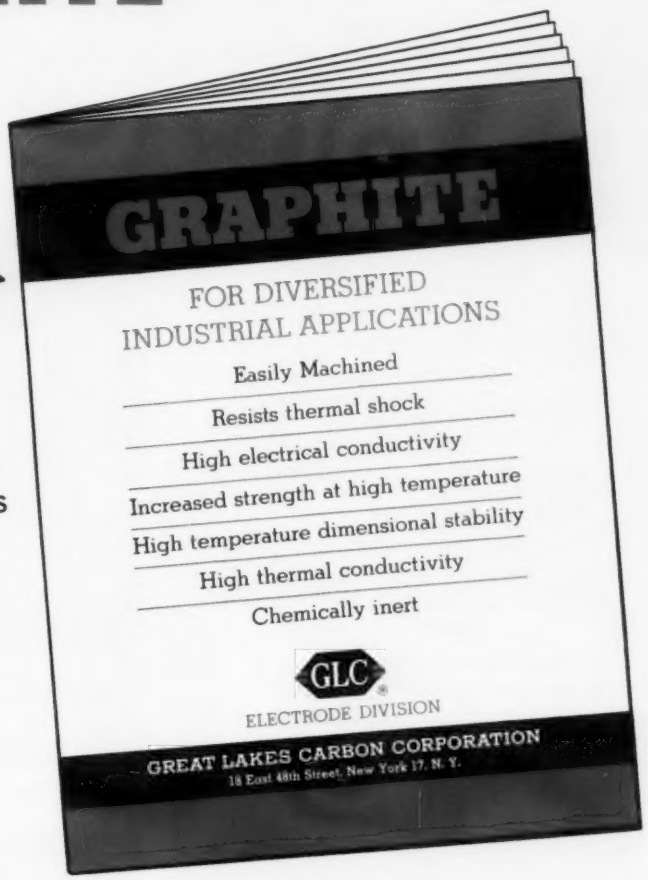
LET US SEND YOU THIS INFORMATIVE BROCHURE ABOUT GRAPHITE



Graphite has a unique combination of physical and chemical properties. Its industrial applications are highly important and greatly diversified.

In metallurgy, graphite is the only practicable material for certain molds and castings. In metal fabricating, it has valuable applications in run-out tables, canisters and brazing fixtures. In refractories, it displays high resistance to thermal shock. New uses for graphite are being found in aircraft, missile and rocket manufacture, and in nuclear power programs.

Here is an informative brochure that outlines graphite's many uses, depicts highlights of its manufacture, and presents facts as to its physical and chemical properties.

Write us for a free copy of **GRAPHITE FOR DIVERSIFIED INDUSTRIAL APPLICATIONS**

You will find this brochure a worthwhile reference.

PRODUCTS ELECTRODE GLC DIVISION YOU CAN TRUST ®

GREAT LAKES CARBON CORPORATION

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FOUR STEEL PRODUCERS own all 12 basic oxygen furnaces operating in this country today (three more are being fabricated in PECor's shops). All four steel producers looked to PECor to build their converters and most of the auxiliary equipment that accompanies them. Supplying basic steel's growing need for heavy equipment is our business . . . has been for nearly 80 years. May we have an opportunity to show how we can help *you?*

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NEW CASTLE, PENNA.
ENGINEERS • FABRICATORS

Blast Furnaces • Scrap Cars
Open Hearth Furnaces • Slag Cars
Oxygen Converters • Hot Metal Mixers
Ore Transfer Cars • Ladles • Jack Cars
Ladle Transfer Cars • Ingot Cars
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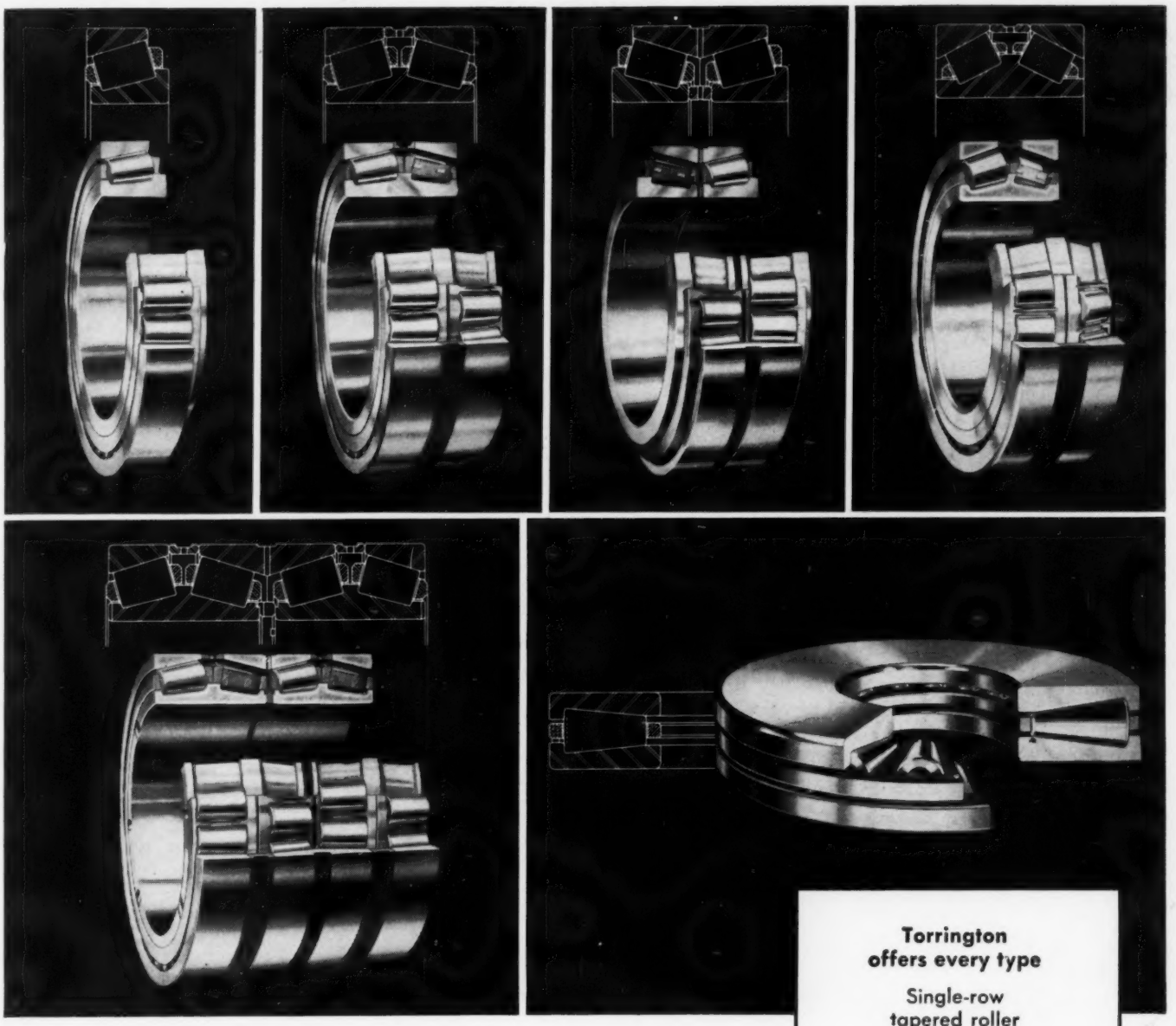

Patterned for performance... Torrington Tapered Roller Bearings

Torrington Tapered Roller Bearings are made to virtually every design pattern for your particular performance requirements.

There are single-row, double-row... four-row tapered roller bearings—all in regular or steep angle design for radial and thrust loads—and conical roller thrust bearings for heavy thrust loads. Each is designed for dependable service in its operation.

Whether your application calls for a catalog bearing, or one custom-built to your specifications, you can rely on Torrington for utmost precision of manufacture, quality material, advanced metallurgy... and engineering experience based on the manufacture and application of every major type of anti-friction bearing.

Torrington offers every type

Single-row tapered roller

•

Two-row tapered roller, solid cone

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Two-row tapered roller, solid cup

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Steep angle, two-row tapered roller

•

Four-row tapered roller

•

Conical roller thrust

•

progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY South Bend 21, Indiana • Torrington, Conn.

Checking gear teeth for accuracy

products

Continuous expansion of facilities maintain The Tool Steel Gear & Pinion Co. leadership in supplying the steel industry with products and services of superb quality. For example, Tool Steel's Maag gear cutter is the biggest in the world. It can cut gear teeth on gears with a 197" diameter and a 20.8" face. It can cut helical gears up to 190" diameter, 15 degree helical; and 177" diameter and 30 degree helical. High quality precision cutting, combined with a rapid delivery schedule, is a service that steel plants receive when they send their big gears to us for cutting or recutting.

"Tool Steel Process" hardened products are available for practically every key point in steel equipment, including screwdown screws and nuts, gears and pinions for all services; track and sheave wheels; leveller, pinch, back-up and coiler carrying rolls; cold rolling rolls, arbors, shafts

...and service unlimited

and axles, sprockets, and mill pinions.

TSP Hardened Products are specifically designed, produced and guaranteed to out-perform, outlast any competitive product in the same service. A special hardening process achieves a file hard surface to the full depth of permissible wear. The core is refined for toughness and ductility.

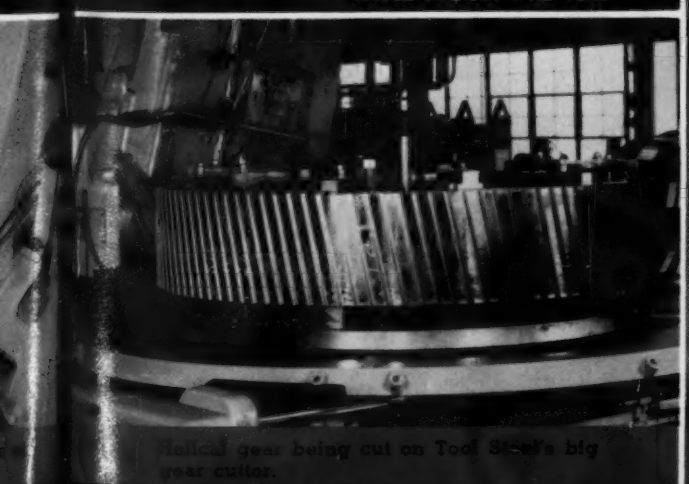
If you're interested in keeping your equipment running better and longer, write today for information on TSP hardened products for the Steel Industry.

THE TOOL STEEL GEAR AND PINION CO. CINCINNATI 16, OHIO

MEMBER OF AGMA

The Standard of Quality Since 1909 for Gears • Pinions • Rolls • Wheels and Other Hardened Products

Printed in U.S.A. AD 1045



Helical gear being cut on Tool Steel's big gear cutter.

TSP gears on end shear depressing table.

TSP table gears and manipulator drive gears on reversing mill.

Screwdown screws, table gears, liner plates, manipulator gears and slides, on 46" blooming mill.

TSP pinion & gear on soaking pit charging crane in continuous service since 1938. No signs of wear.

TSP pinion and drum gear for crane trolleys.

Wheels, gears and axles on overhead cranes.

Crane trolley drive assembly; spur gear, double helical shaft pinions, herringbone ring, cent... assembly, mating shaft pinion.

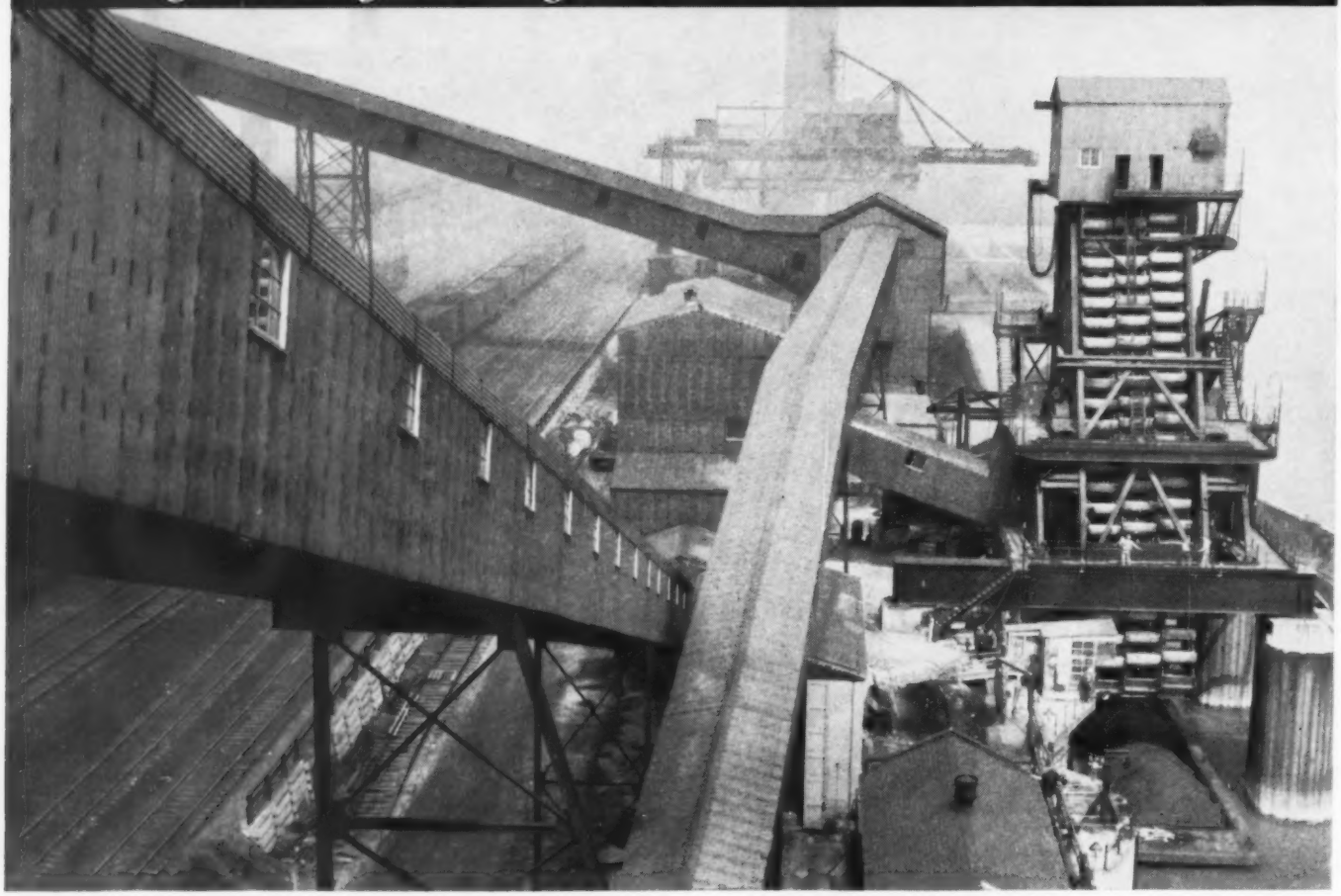
TSP drum pinion in service on skull cracker crane since 1943.

TSP gears and pinions in ... head mortar.

TSP reel drive gear—for seamless tube mill.

You get Undivided Responsibility for your Material Handling Plant from ROBERTS & SCHAEFER

Design... Engineering... Fabrication... Construction



From blueprint to turn-key delivery, Roberts & Schaefer will take entire responsibility for your material handling plant.

You will find at Roberts & Schaefer a unique combination of creative engineering talent, long experience in the specialized material handling field, and large facilities for fabrication and construction.

You tell us the capacity, flexibility and performance you want. Roberts & Schaefer will design and build a plant complete with coordinated processing, distributing and storage systems to satisfy your requirements for operating efficiency and economy.

Whether your material handling project involves a complex system, as illustrated here, or a simple operation, you'll find it well worth while to talk first with Roberts & Schaefer.

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DIVISION OF THOMPSON-STARRETT COMPANY, INC.

Publication Service...

MAY, 1960

You Can Obtain . . .

. . . any of the bulletins reviewed in the Publication Service of the IRON AND STEEL ENGINEER without obligation or cost. Simply circle the desired item numbers on one of the prepaid postal cards and mail. The requests will be forwarded to the manufacturers involved who will send the bulletins to you.

Note: Post cards expire three months after publication date.

(1) Magnet Repair

Full details on a typical magnet repair are contained in a booklet published by Westinghouse Electric Corp. The booklet illustrates the modernization of magnets by skilled craftsmen using special processes and facilities. How magnets are modernized at the cost of only the repair is also explained.

(2) A-C Magnetic Starters

Available from The Clark Controller Co. is an 8-page bulletin covering engineering data on their Type "CY" starters. The arc quenching principle, used on the size 2, 3 and 4 is fully described and diagrammed. The enclosures, form and combinations of these starters are also shown.

(3) Heat-Resistant Castings

Research, design, development and production of their high-alloy heat-resistant castings for the steel industry is the subject of a new bulletin issued by Electro-Alloy Div., American Brake Shoe Co. This comprehensive bulletin discusses customizing existing alloys to reduce steel's maintenance and replacement costs, the creating of new designs. Fully illustrated, the bulletin also includes a case history of grid-type tray, and a case history of heat-treat furnace I-beam.

(4) Heat Treating Stainless Steel Products

The Drever Co., has released a new bulletin covering the use of Drever furnaces and equipment for heat treating stainless steel as strip, sheet, tube, wire, bar and formed and machined products. This 16-page bulletin pictures and describes the types used in each operation and covers the latest developments in continuous, semi-automatic and batch methods for heat treating stainless steel products. (Bulletin B-81)

(5) Pump Motors

Wagner Electric Corp. has issued a bulletin describing their doubly-protected dripproof and totally-enclosed polyphase squirrel-cage motors, 1 hp and larger, with NEMA "C" faceplates for close-coupled centrifugal pump applications. The bulletin covers, by use of cut-away photos, the particular electrical and mechanical features of the motors that make them prime working partners with close-coupled centrifugal pumps. (Bulletin MU-244)

(6) Continuous Galvanizing Lines

Blaw-Knox Co., Aetna-Standard Div., has issued a booklet discussing their continuous galvanizing lines. The booklet answers such questions as: What is the difference between one galvanizing line and another? How can you save money on the purchase of a continuous galvanizing line? What are the different components that must be considered in the designing of a line? Other information includes data on the number of lines operating in the world; and pictures of different components of continuous galvanizing lines.

(7) Industrial Products

A bulletin describing in brief the company's complete line of products is now available from American-Standard Industrial Div. The 24-page bulletin describes and gives basic ratings for the air conditioning and air handling equipment, fluid drives, heat exchangers, surface condensers, steel boilers and related industrial products made by the Division. (Bulletin B-5529)

(8) Potentiometers

A two-page data sheet describes Leeds & Northrup Co.'s new 8692 single-range and the 8693 double-range portable temperature potentiometers and their advantages for making accurate temperature or millivolt measurements in industrial plants or in research laboratories. A simplified range-change method is described and all 24 interchangeable temperature and millivolt ranges are tabulated. Complete specifications are listed and ordering instructions are included. [Data Sheet ND 42-33 (1A)]

(9) Replacement Coils

Information and data on their replacement coils, which are manufactured to original equipment size and electrical design, are contained in a new bulletin issued by General Electric Co. The four-page booklet describes how problems of overheating and improper speed are avoided, insuring longer life for all electrical parts. Resistance values and physical dimensions of armature and field coils are held to the close original equipment tolerances required to insure proper current and ventilation to all electrical components of General Electric MD motors. (Bulletin GEA-7041)

(10) Basic Guide to Ferrous Metallurgy

A basic guide to ferrous metallurgy is available from Tempil Corp. This data sheet includes a chart giving the subzero range, black heat range, red heat range and white heat range. Also discussed are forms of iron, anneal-

ing, normalizing, etc. Temperature indicating crayons are described as well.

(11) Linear Flow Transmitters

Bailey Meter Co. has available a product specification booklet describing their force balance pneumatic transmitters. Selection table lists ranges from 0.1 in. to 0.2000 in. H_2O, service pressures and weights. (Product Specification P22-1)

(12) Plant Equipment

Ingersoll-Rand Co. has published a new booklet entitled, "Products for the Plant." This literature is available to anyone with an interest in the selection and supervision of plant equipment. Standard reciprocating, axial-flow and centrifugal air compressors, centrifugal pumps, steam condensers, steam-jet ejectors, vacuum pumps, air hoists and air and electric tools are all covered in this booklet. Representative machines in each product line are illustrated and outstanding design features noted. This booklet also gives the size and capacity ranges of the many units, as well as recommended applications. (Form 223)

(13) Lifting Magnets

Lifting magnets designed specfically for scrap handling are described in a bulletin published by Stearns Magnetic Products. Complete data and specifications are given in the bulletin. A dimension drawing of the new lifting magnet is included. (Bulletin No. 3021)

(14) Speed Recorder

The Esterline-Angus Co. announces the publication of a bulletin which describes and illustrates up-to-date applications of their speed recording system. It also includes a complete description of the use of speed relays to protect belt conveyors. (Bulletin 260)

(15) Belt Conveyor Idlers

A new 48-page engineering and product information booklet on belt conveyor idlers has been issued by Hewitt-Robins Inc. Included are details of construction, comparison of 10 competitive designs, selection, procedure and examples, engineering tables, dimensions and specifications. The catalog illustrates and describes the basic types of idlers used in all types of service—troughing, impact, troughing trainer, transition, deep trough, return, flat belt, impact feeder, return trainer, feeding and picking, live shaft flat belt impact, wire rope, and rubber spiral idlers. Detailed information is presented on most of the standard 134 styles of idlers which Hewitt-Robins manufactures. (Bulletin 171)

(16) Heat Treating Processes

Surface Combustion, Div. of Midland-Ross Corp., has published a review discussing heat treating processes. The lead article is devoted to a discussion of nonferrous metal heat treating and the application of prepared gas atmospheres. Another article describes the need for flexible equipment in job-shop operations. It also tells how a commercial heat treating concern devised a heat treating line which economically incorporated this feature.

(17) Lubrication

A booklet released by Mobil Oil Co. graphically illustrates the cost-saving importance of a comprehensive lubrication program. Included is the example of a large transportation equipment manufacturer who saved 43,907 machine production hours, cut downtime more than 36 per cent, and saved $50,280. The booklet is written for plant managers and maintenance supervisors. It emphasizes the originality, scope and effectiveness of a well planned lubrication program. Since no two plants are the same, the booklet points out, lubrication engineers work closely with plant and maintenance people to develop a program geared to a particular situation.

(18) Plating Solutions

A 36-page, two-color booklet offered by Hanson-Van Winkle-Munning Co., describes simple analytical methods for plating solutions. The procedures outlined may be easily and rapidly carried out by nontechnical personnel. It is prefaced by a discussion of analytical principles, use of apparatus and methods for sampling a plating solution. The booklet outlines in detail the step-by-step procedures involved in a number of analytical methods for testing nickel, copper, silver and other metal-finishing solutions. Other sections of the booklet describe necessary equipment, component chemicals of solutions, atomic weights, acid concentrations and electro-chemical data. Conversion tables are included. Analytical reagents are listed for all types of plating solutions. Pictures of their laboratory illustrate different test operations performed, which are available to company customers.

(19) Electric Hoist Control Switches

Nine switches for electric hoist control are described in an 8-page illustrated bulletin published by Joy Manufacturing Co. A unique fold-back in one of the pages of the bulletin gives the reader a quick front, back and interior view of the station, showing the switch well, water seals and the micro-type positive switches in proper position. Information is also provided on the Joy line of toggle and other types of molded-to-cable switches.

(20) Aluminum Vaportight Lighting Fixtures

The Pyle-National Co. announces the availability of a bulletin describing the design, materials and reliability features of a new complete line of industrial vaportight lighting fixtures. Details give labor saving features, technical data, catalog numbers and prices. (Bulletin No. 652)

(21) Contractor Buckets

A 32-page catalog covering all types and sizes of their clamshell and dragline buckets and stone grabs has been published by Williams Bucket Div., The Wellman Engineering Co. Detailed information describing the principles of bucket operation and selection as well as complete, easy to read specification charts are included.

(22) Iron Castings

The engineering facilities and services used in the production of castings from a wide range of iron alloys are presented in a 12-page illustrated brochure published by Hamilton Foundry Inc. The brochure also contains a useful comparative properties chart and description of the standard, high nickel and ductile irons produced.

(23) Rust-Proofing Liquids

Rust-Lick, Inc., has published a brochure covering their line of products developed specifically to meet the requirements of an integrated ultrasonic cleaning and rustproofing system. Ultrasonic liquid cleaning concentrate is described and the factors involved in the selection of rust preventives for use after cleaning are explained.

(24) Electric Controls Brochure

Warner Electric Brake & Clutch Co. offers a new electric controls brochure describing in detail their line of standard, special and custom controls used to actuate Warner electric brakes and clutches. Included are sections on description, operation, dimensions and selection. (Form P-75)

(25) Resistance Welding

A 24-page brochure with photographs of 268 welded products and 20 photographs of welders and laboratory facilities is available from The Taylor Winfield Corp. Included are actual case histories showing how modern resistance welding machines are selected or specially engineered for the needs of particular welded products. Types of welding shown are: spot, seam, projection, arc, flashbutt, upset-butt; also metal gathering; on many types of ferrous and nonferrous metals including: stainless steels, copper, aluminum, Inconel X, terne plate, etc. (Bulletin SP-18)

(26) Aluminum Manual

A complete survey of aluminum welding, brazing and soldering is included in a comprehensive, practical, 40-page illustrated manual by All-State Welding Alloys Co., Inc. Among subjects covered are welding aluminum and its alloys by inert gas-shielded metal arc with a consumable electrode, inert gas-shielded metal arc with a tungsten electrode and the latest arc and gas welding processes. Chapters are also devoted to aluminum brazing with an introduction and detailed description of aluminum brazing alloys, brazing by torch, cleaning and finishing after brazing and charts of brazeable aluminum alloys. The soldering section includes melt and flow charts, how to solder aluminum to other metals and instructions on aluminum soldering with torch or iron—with or without flux. The manual contains twelve charts on the composition of aluminum alloys, their technical and physical properties, recommended filler alloys for MIG and TIG welding. In addition, composition and properties of their brazing filler alloys and melt and flow charts are given. A complete list of their aluminum joining products and fluxes, said to be the largest aluminum line in its field, is included with government specifications covered by these alloys.

(27) Oil and Grease Seals

The Garlock Packing Co. has published a comprehensive catalog on their oil and grease seals for bearings. A general description of the seals is given as well as installation instructions. Also discussed is a complete description of the models and their size or size ranges. Engineering reference tables, a chart indicating possible sources of seal trouble on general applications and a visual index to the models made are included. (Catalog 30)

(28) Unit Substation Workbook

A comprehensive workbook to aid in planning articulated unit substations for secondary distribution has just been released by Pennsylvania Transformer Division, McGraw-Edison Co. Ratings, weights and dimensions are included for efficient planning of low-voltage substations for secondary distribution systems. Types of load centers and substations are described for both indoor and outdoor applications. Detailed specifications are provided for incoming supply sections, transformer sections and outgoing feeder assemblies, both indoor and outdoor. The workbook features a suggested specification form which details all data needed for a properly co-ordinated substation system. Transparent copies of this form are available for engineering department reproduction.

(29) Ladle Additions Feeder

Advantages of automatic ladle additions feeders that provide greater additive recovery and improved ingot quality at lower cost during steelmaking are described in a bulletin now available from Blaw-Knox Co. The eight-page brochure describes the simple three-step process of loading, positioning and controlled feeding employed with the units. In addition, it details types and mountings —tailored for plant operating conditions; and reviews vibrating and weighing controls designed for uniformity and increased production. (Bulletin 2578)

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53	ATLAS CAR & MFG. CO.	BULLETIN 1283	Transfer cars
54	BABCOCK & WILCOX CO., THE	BULLETIN R-2-H	Insulating firebrick
55	BLISS CO., E. W.	BULLETIN NO. 60	Pulsation burner
56	BLISS CO., E. W.	CATALOG 40-B	Rolling mills
57	CLEVELAND WORM & GEAR DIV., EATON MANUFACTURING CO.	BULLETIN NO. 145	Speed reducers
58	COLUMBUS MCKINNON CHAIN CORP.	BULLETIN 100	Sling chains
59	CONE-DRIVE GEARS DIV., MICHIGAN TOOL CO.	BULLETIN CD-218	Hollow shaft speed reducers
60	COWLES TOOL CO.	BULLETIN NO. 571	Slitting and trimming knives
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67	GENERAL ELECTRIC CO., THE	BULLETIN GEA-6858	Punched grid resistors
68	GENERAL ELECTRIC CO., X-RAY DEPT.	PUB. IS-54	X-ray emission gage
69	GENERAL STEEL CASTINGS CORP., NATIONAL ROLL & FOUNDRY DIV.		National Roll's expanded staff and facilities
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71	GPE CONTROLS, INC.		Electronic controllers
72	GREAT LAKES CARBON CORP.		Graphite
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76	JOHNS-MANVILLE	IN-190A	Insulation
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78	LARCO, INC.	BULLETIN AC-573	Crane cab and pulpit air conditioners (Aire rectifiers)
79	LINK-BELT CO.	BOOK 2719	Speed reducers
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81	NUKEM PRODUCTS CORP.		Cements
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93	TAYLOR INSTRUMENT COS.	CATALOG 98335	Electronic transmitter
94	UNION CARBIDE METALS CO.	F-20,123 AND F-20,125	Exothermic ferrochrome and exothermci ferromanganese
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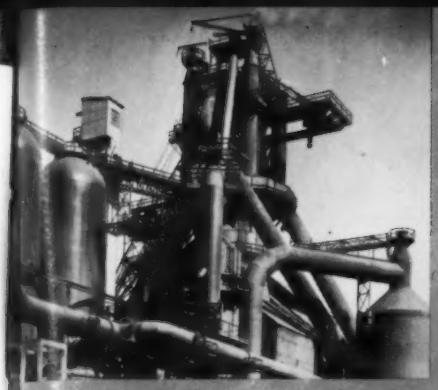
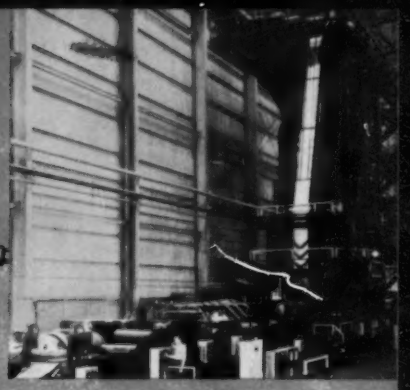
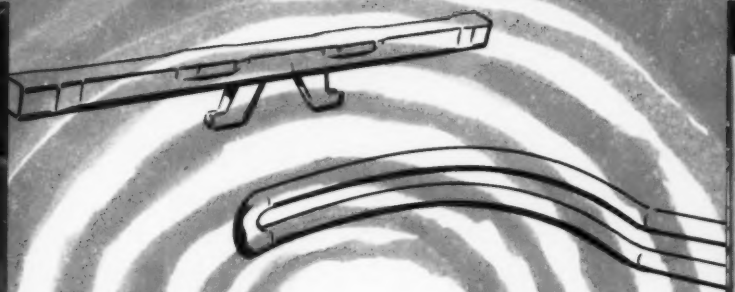


Blast Furnace Blowpipes

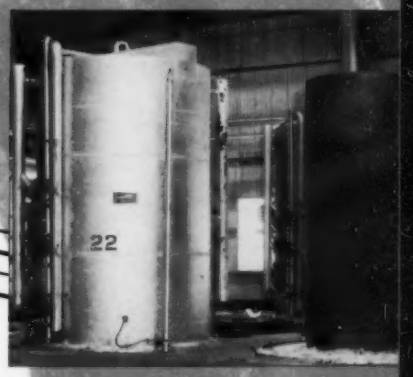


Continuous-Strip Annealing Furnace Rolls

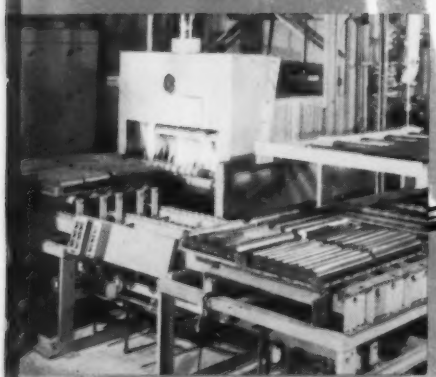
Sintering Machine Grate Bars



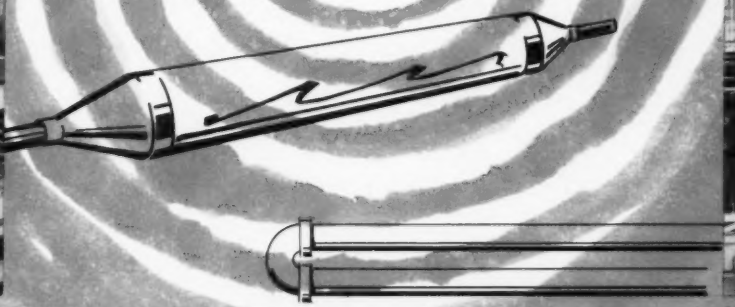
heat resistant castings

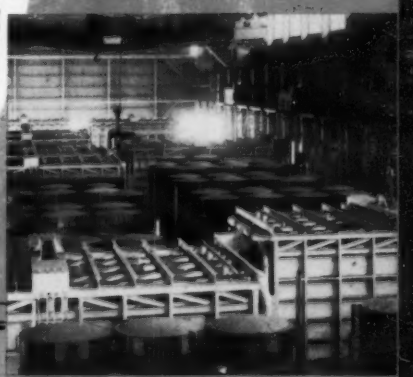


Single-Stack Annealing Furnace Radiant Tubes

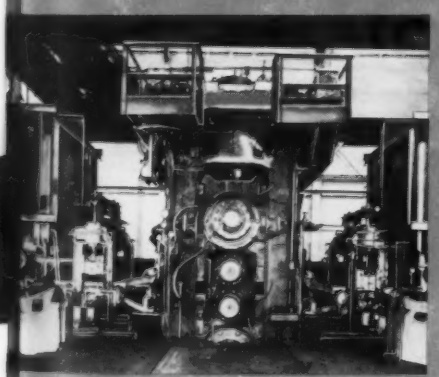


Roller Hearth Furnace Rolls

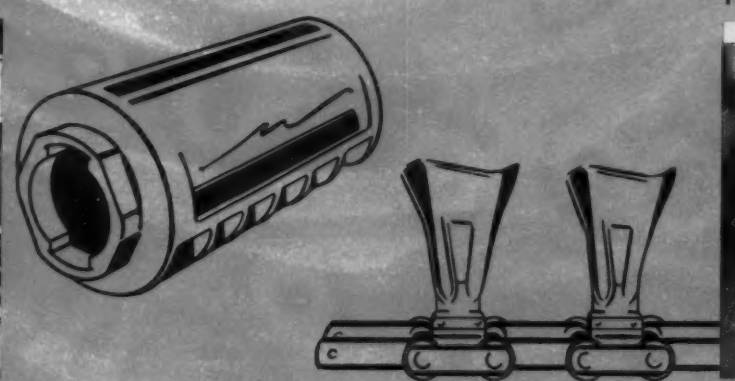


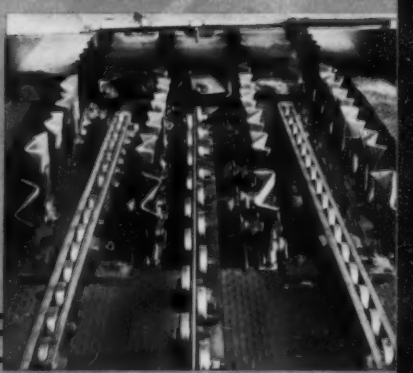


Multiple-Stack Annealing Furnace Radiant Tubes



One-Stand Four-High Reversing Mill Coiler Drums





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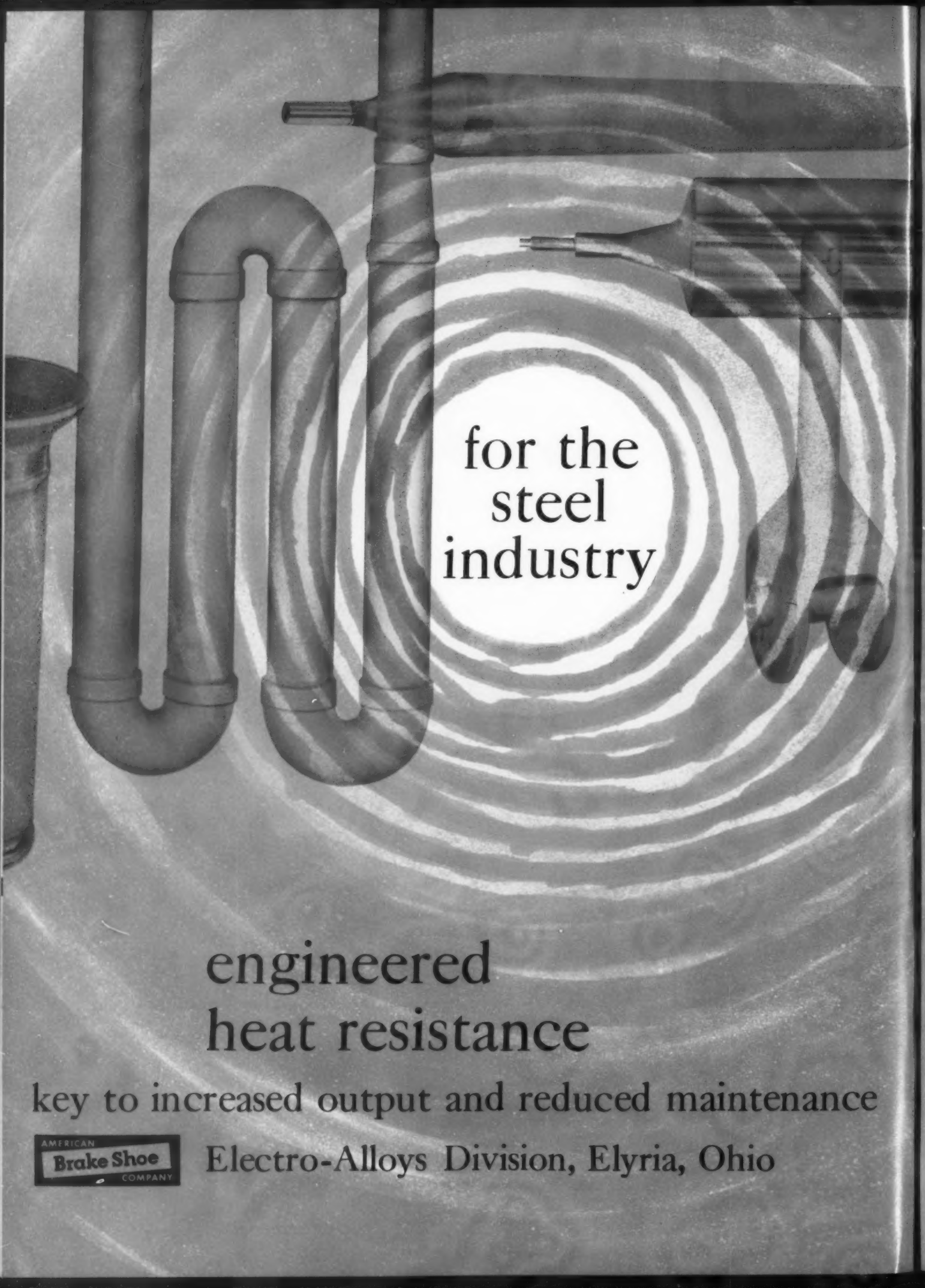

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key to increased output and reduced maintenance

AMERICAN Brake Shoe COMPANY

Electro-Alloys Division, Elyria, Ohio

METALGRAMS

UNION CARBIDE METALS

. . . news about "Electromet" ferroalloys and metals

MAY, 1960

NEW EXOTHERMIC CHROMIUM SAVINGS -- Open-hearth melters using an exothermic ferrochrome ladle practice can save from 50 to 60 cents per ton by using new "Chromtemp" ferrochrome 25-6. The silicon content of the alloy (6.25 lbs. per can) saves the steelmaker money by replacing separate ferrosilicon additions required with straight chromium exothermic alloys. Your Union Carbide Metals representative will be glad to give you further information.

* * *

EXOTHERMIC WITH MORE HEAT -- Closer control of large open-hearth ladle additions can now be obtained with the greater exothermicity of "Chromtemp" exothermic ferrochrome and "Mantemp" exothermic ferromanganese. The improved reaction promotes greater stirring, minimizes segregation, and dissolves the alloy faster. The result is better control of alloy analyses, resulting in fewer off-grade heats. Specification sheets for these alloys may be obtained by requesting F-20,124 and F-20,125.

* * *

LESS GAS THAN EVER -- Producers of vacuum-melted steels and high-temperature alloys have improved their melting operations with new "Elchrome" VG electrolytic chromium. Having less than 0.06 per cent oxygen and extremely low hydrogen and nitrogen contents, this high-purity vacuum-grade chromium has the lowest gas content commercially available. As a result, it's easier to maintain a vacuum and there's less spattering and boiling in the bath. Ask your Union Carbide Metals representative for the analysis of this improved chromium metal.

* * *

EYES ON PHILADELPHIA -- Foundrymen interested in the latest uses of ferroalloys to produce better castings will want to visit Union Carbide Metals' extensive exhibit at the 64th AFS Castings Congress and Exposition, May 9-13, in Philadelphia. The Union Carbide Metals' exhibit covers 41 foundry alloys. Featured are alloys that give better properties to cast iron, allow more efficient production of ductile iron, cut costs of steel, and give greater purity to aluminum. Experienced UCM metallurgists and engineers will be on hand to provide on-the-spot assistance. You are cordially invited to visit the exhibit and talk to UCM personnel. See us at booth No. 1214.

* * *

GASES ARE FLUSHED OUT -- A new alloy -- magnesium-calcium-silicon -- has been used successfully to flush out gases in high-alloy heats melted in the induction furnace. The alloy is added to the ladle and produces a vigorous flushing action. One producer reduced his rejection rate caused by gas imperfections from 30 to 5 per cent on a 35 per cent nickel, 15 per cent chromium casting. For the case history, write for the article, "Rejections Cut With New Alloy," in the Winter 1960 issue of UNION CARBIDE METALS REVIEW or contact your UCM representative for further details.

* * *

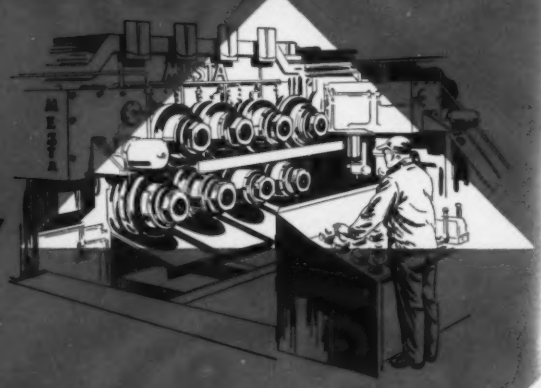
UNION CARBIDE METALS COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. In Canada: Union Carbide Canada Limited, Toronto.

"Chromtemp," "Elchrome," "Electromet," "Mantemp," and "Union Carbide" are trade marks of Union Carbide Corporation.

WIDE FLANGE BEAM and STRUCTURAL MILLS

Designed and Built by MESTA

Rolling Wide Flange Beams in the 40" Finishing Mill Stand on the MESTA Universal Structural Mill at Inland Steel Company



Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA

Personnel News...

John L. Young was named vice president—engineering technology, United States Steel Corp. In his new position, Mr. Young will be concerned with foreign and domestic engineering developments. The appropriations activities previously directed by Mr. Young will be consolidated under **J. D. Rollins** whose title will be changed to vice president—facility planning and appropriations.

Mr. Young joined U. S. Steel's National Tube Division in 1945 as vice president in charge of engineering and construction. In 1951 he was made vice president—chief engineer, U. S. Steel, and a year later he became vice president—engineering for the corporation. He was named vice president—appropriations in 1958, the position he held prior to his present appointment.

Mr. Rollins joined U. S. Steel in 1934 with the American Sheet and Tin Plate Co. as an estimator. Three years later he was transferred to the Gary Works where he attained the position of chief engineer. In 1948, he returned to Pittsburgh as planning engineer and in 1950 was made assistant chief engineer for Carnegie-Illinois, a former subsidiary company. In 1951, Mr. Rollins became assistant chief engineer—manufacturing, U. S. Steel, and the following year he was promoted to assistant vice president—engineering for the corporation. In 1955, he was named vice president—engineering for American Bridge Division, and in 1958 he was appointed to the position he held prior to his present appointment.

C. D. Smith has been appointed assistant manager, Production Planning Department at Jones & Laughlin Steel Corp.'s Pittsburgh works. He formerly was assistant superintendent of the Strip Sheet Department. **Samuel A. Ambler** succeeds Mr. Smith as assistant superintendent of the Strip Sheet Department. He formerly was general foreman of the Continuous Galvanizing Department.

Mr. Smith has been a J&L employee at the Pittsburgh Works since 1939 when he started as a metallurgical inspector at the Open Hearth Department. He has held metallurgical positions in the blooming mill, open hearth and blast furnace departments, and also has held various operating positions in the blast furnace, open hearth and strip sheet mill departments. He had been assistant superintendent of the Strip Sheet Mill Department since 1958.

Mr. Ambler has been a J&L employee at the Pittsburgh Works since 1948, when he started as assistant supervisor of rates. He also has been supervisor of planning and cost analysis, and assistant works industrial engineer. He had been general foreman of the Continuous Galvanizing Department since 1955.

Roy T. Lewis has been appointed division assistant chief engineer, Jones & Laughlin Steel Corp.'s Stainless and Strip Division. He formerly was design engineer supervisor. **Ernest D. Sevenich** has been appointed a project engineer. He formerly was a design engineer at the division's Youngstown, Ohio, plant. **Emory C. Walton** has also been appointed a project engineer. His former position was design engineer at Youngstown.

C. J. Duby retired recently after serving as chief engineer of the International Projects Div., of Republic Steel Corp. This ended over 51 years of service in the steel industry, primarily with Republic Steel Corp. and predecessor companies in the Youngstown and Warren, Ohio, districts. Mr. Duby was chief engineer in Warren since 1931. Since 1956, he has been helping build steel plants in Madrid, Spain, and Havana, Cuba. He has been active in the AISE, and is a life member.

Arthur Carlson has been elected vice president of production for A. Finkl & Sons Co. Mr. Carlson has been with the company for 25 years, and was formerly assistant production manager.

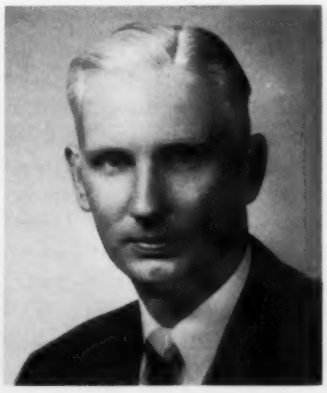
Robert W. Hanlon has been named general superintendent of the Coke and Iron Division of Pittsburgh Coke & Chemical Co. Prior to his new appointment, Mr. Hanlon was superintendent of the Coke Plant at Neville Island. He joined Pittsburgh Coke & Chemical

J. L. YOUNG

J. D. ROLLINS

C. D. SMITH

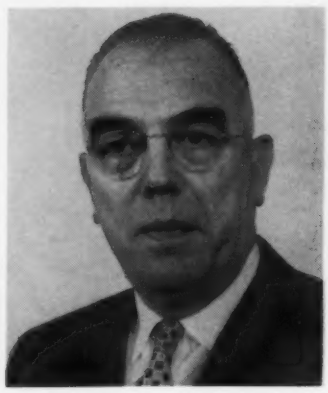
S. A. AMBLER



J. R. FERGUSON, JR.

P. S. WEAVER

SAMUEL NAISMITH



AKSEL TULINIUS

Co. in 1933 and in 1941 he was named by-products foreman.

J. Robert Ferguson, Jr., has been appointed assistant vice president—design and construction in the Engineering Department of U. S. Steel Corp. Mr. Ferguson was formerly assistant vice president—appropriations. Mr. Ferguson began his career with U. S. Steel in 1940 as a special engineer in the Pittsburgh general offices. He was transferred to the Chicago area in 1941 and advanced through various engineering positions until 1947 when he was named assistant works chief engineer, South Chicago Works. In 1950, he was appointed assistant to the general superintendent at that plant. Later in 1950, Mr. Ferguson became appropriation control and project engineer of the Orinoco Mining Co., a subsidiary of U. S. Steel. One year later he was named assistant chief engineer with headquarters in New York, and in 1952 was transferred to Venezuela in the same capacity. Mr. Ferguson returned to the Pittsburgh offices in 1954 as chief engineer—project development, and in 1955 was appointed assistant vice president—engineering. In 1958 he was named assistant vice president—appropriations.

P. S. Weaver was appointed assistant vice president—appropriations and **Samuel Naismith** was named assistant vice president—facility planning, U. S. Steel Corp. Mr. Weaver first started with U. S. Steel in 1933 as an industrial engineer at the Clairton Works. He advanced through various industrial engineering positions in Pittsburgh district plants until 1943 when he was named superintendent—production planning at the South Chicago Works. Successively, he was named assistant to the general superintendent, superintendent—Wide Flange Structural Department, and assistant general superintendent of the works. In 1955, Mr. Weaver was appointed to the position of chief engineer—project development, the position he held prior to his present appointment. Mr. Naismith joined U. S. Steel in 1936 at the South Chicago Works. After various appointments, in 1951 he was named supervisor, ore movement with Oliver Iron Mining Co., a subsidiary of U. S. Steel. In 1952, he became assistant chief engineer—manufacturing, and in 1954, was appointed assistant chief engineer—appropriations and budgets. Mr. Naismith was appointed project development engineer—blast furnaces in 1955, and in 1956 became project analysis engineer in the Engineering and Raw Materials Department. In 1958 he was appointed project analysis engineer in the facility planning department of engineering and research, the position he held prior to his present appointment.

Aksel Tulinius has been appointed chief mechanical engineer, Design and Construction Department, Brackenridge Works of Allegheny Ludlum Steel Corp. Mr. Tulinius had been in engineering work in the Pittsburgh area steel industry for 28 years before joining Allegheny Ludlum as chief draftsman, General Engineering Department, in 1953. He held this post until his promotion.

William N. Moore was named assistant superintendent of the Inspection and Steel Conditioning Department at Republic Steel Corp.'s South Chicago, Ill., plant. Mr. Moore has been general foreman of the department since 1950. He joined Republic in 1934 as an inspector and served in various other assignments in the department prior to 1950.

R. M. Hadcock has been appointed superintendent of the Blast Furnace Department at Republic Steel Corp.'s Warren, Ohio, plant. Mr. Hadcock, formerly assistant superintendent, succeeds **K. G. LeViseur** who has retired. **H. W. Ritter** replaces Mr. Hadcock as assistant superintendent. A veteran of 27 years of service with the company, Mr. Hadcock joined Republic in 1933 at the Cleveland plant. He held a number of positions in the Blast Furnace Department there and in 1944 was transferred to Warren as assistant superintendent. Mr. Ritter joined Republic as a

R. M. HADCOCK

H. W. RITTER

ARMCO

WHEELING STEEL

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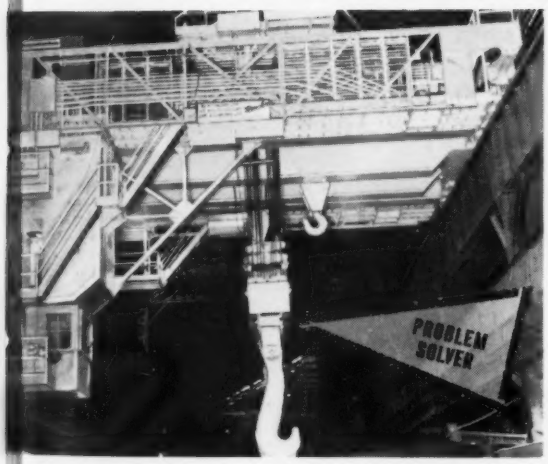

Shaw-Box Ladle Crane. A 4-girder, 9-motor crane with 54 foot span. 90-ton ladle holds 200 tons of molten steel. 75-ton auxiliary trolley handles lighter loads.

Shaw-Box Bucket Magnet Gantry Crane. Our gantries are used to handle plate, slabs, ingots, and scrap. They are built to obtain freedom from whipping and to resist impacts.

These 10 top steel companies solve handling problems with Shaw-Box® Cranes

Standard crane designs of 30 years ago can't solve materials handling problems for today's steel mills. Problems unique to each mill demand cranes especially engineered for the job.

That is why these ten leading steel companies developed their own crane specifications — or chose modern AISE standards. Each awarded the job of constructing the crane to Shaw-Box.

Shaw-Box produces cranes of any type and capacity to AISE standards or your own. Your particular materials handling problems come first. We are not bound by traditional concepts of design. The crane you want is developed for top efficiency, easy maintenance, power economy, and complete safety.

Call in one of our engineers. He will gladly discuss specifications and tell you about our standard AISE designs for 5 to 500-ton cranes. We welcome the opportunity to serve you.

MAXWELL MANNING & MOORE INC. M&M TRADE MARK

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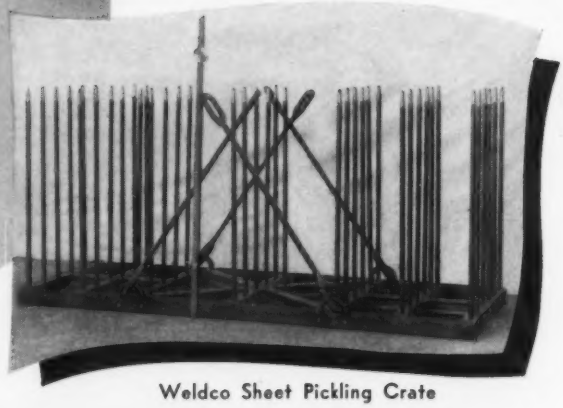
WHAT'S YOUR PICKLING PROBLEM

WELDCO SPECIALISTS HAVE THE ANSWER!

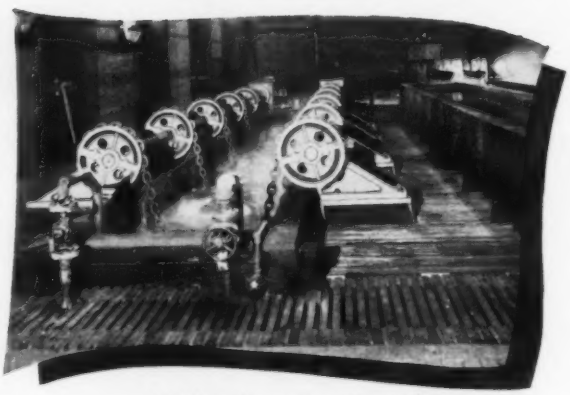
IN HUNDREDS of plants, you'll find Weldco equipment all along the pickling line. For Weldco products are made of corrosion-resisting, hot rolled metals, which withstand attack from hot acids and other pickling solutions. They are strong yet lightweight, wear-resistant, durable, and long-lasting. You get all these advantages when you specify Weldco hooks, mechanical picklers, crates, baskets, racks, chain, steam jets, and accessories.

Weldco offers a complete, well-designed line of pickling equipment . . . plus the services of our experienced staff. Let Weldco engineers take care of all your pickling needs. For any problem, large or small, they have the practical, cost-cutting answer.

Weldco Pickling Hooks

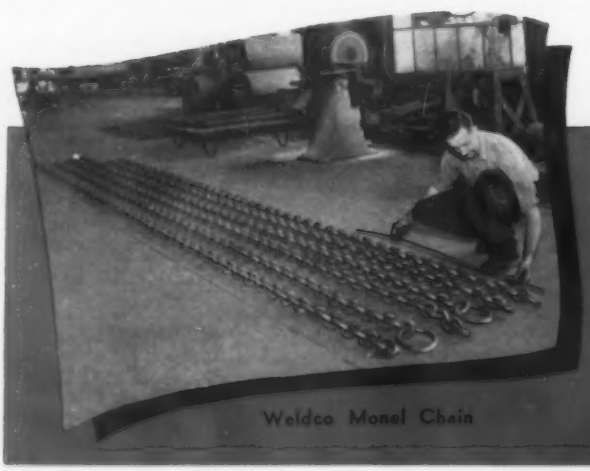


Weldco Sheet Pickling Crate



Weldco Mechanical Bar Pickler

Weldco Mechanical Coil Pickler



Weldco Monel Chain

THE YOUNGSTOWN WELDING & ENGINEERING COMPANY

3720 OAKWOOD AVE. · YOUNGSTOWN 9, OHIO

technical operating trainee at the Warren plant in 1947.

Lewis J. Trauthwein has been appointed superintendent of the Blast Furnace Department of the Hamilton, Ohio, plant of Armco Steel Corp. He succeeds **E. A. Kercamar,** who died recently. Prior to his promotion, Mr. Trauthwein was general foreman of the department.

William R. Hough, since 1948 vice president of engineering for The Reliance Electric and Engineering Co., has been assigned to a new executive position in the company as vice president of research, development and engineering. Mr. Hough will direct an over-all company activity beamed at research for new products and systems and including product development and engineering. Mr. Hough has been a director of the company since 1954. He joined Reliance in 1929, and progressed through several positions, becoming chief engineer in 1945.

H. R. Edelman, III, was elected executive vice president, Heyl & Patterson, Inc. Mr. Edelman had been vice president in charge of production. **J. F. Page** has been elected vice president—assistant to the president and treasurer. He was formerly vice president and treasurer.

Charles F. O'Riordan was named manager of the North Central region, Industries Group, Allis-Chalmers Manufacturing Co. He succeeds **M. M. York,** who has been assigned to a new position in Milwaukee. Since 1956, Mr. O'Riordan had managed the company's Midwest region, with headquarters in St. Louis, Mo.

Robert E. Morris succeeds Mr. O'Riordan there. Mr. Morris had been a sales representative in the Charlotte, N. C., and Washington, D. C., districts, manager of industrial sales in the Washington office, and manager of the St. Louis district prior to his latest appointment.

R. L. Allshouse was recently appointed assistant sales manager of The Wean Engineering Co., Inc. Mr. Allshouse will also continue his duties as European sales representative.

Ned A. Ochiltree, president of Ceco Steel Products Corp., was elected chairman of the board and **C. Foster Brown, Jr.**, executive vice president, was elected president. Mr. Ochiltree is chief executive officer and Mr. Brown is chief operating officer.

Eugene R. Dean has been promoted to assistant general superintendent—Coke and Iron Division of Pittsburgh Coke & Chemical Co. Mr. Dean had been superintendent of blast furnaces at the company's Neville Island plant. Before joining Pittsburgh Coke & Chemical in 1947 he was in the blast furnace department of The Youngstown Sheet & Tube Co.

Frederick B. Miller has been named digital applications supervisor to co-ordinate sales, engineering and installation of computer-controlled systems for Republic Flow Meters Co., a subsidiary of Rockwell Manufacturing Co. Mr. Miller comes to Republic from W. A. Kates Co. where he was sales manager for two years. He had been with Republic ten years prior to that. His last position with Republic was manager of the Cleveland sales district.

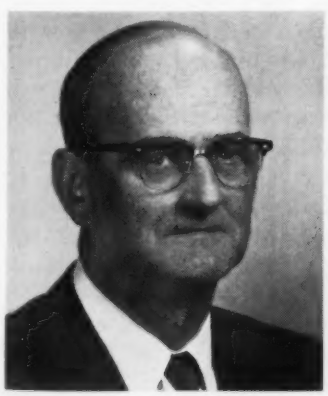
Robert L. Halsted was named manager of the Milwaukee district, Allis-Chalmers Manufacturing Co., Industries Group. He succeeds **A. P. Bowman,** who has been transferred to North Central regional headquarters in Chicago, Ill., as manager of Industrial Equipment Division sales. Mr. Halsted joined Allis-Chalmers in 1935 as a sales representative in the Cincinnati, Ohio, district office. He later became manager of the Charleston and Cleveland districts and manager of sales for the Central region.

William N. Cooper has been named assistant superintendent of maintenance at the Campbell Works of The Youngstown Sheet and Tube Co. He started with the company in 1948 as a student engineer. He previously had served as night master mechanic, general steam foreman and supervisor of maintenance planning and scheduling.

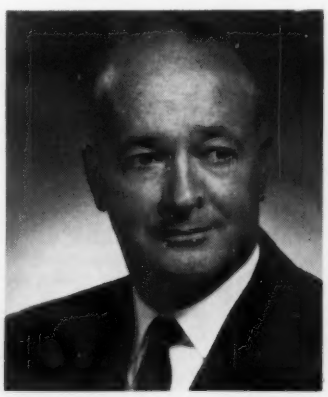
Clare K. Tubbs has been appointed manager of industrial sales, Pittsburgh district, by Allis-Chalmers Manufacturing Co. He had been a sales representative in the Dayton, Ohio, district for three years and prior to that in the Detroit, Mich., district for six years. He has been with Allis-Chalmers since 1949.

Glenn Jorn has been appointed to manage the Western Gear Corp.'s newly-opened Cleveland District office. He was previously district marketing manager

L. J. TRAUTHWEIN



W. R. HOUGH



H. R. EDELMAN III

J. F. PAGE

GLENN JORN (left)
C. A. LOVGREN (center)
E. F. SCHERR (right)

of the company's Southwestern Division at Houston, Texas.

C. A. Lovgren has been appointed assistant to the president of Swindell-Dressler Corp. Mr. Lovgren comes to the firm from National Carbon Co. where he was division manager.

Eugene F. Scherr was named manager of the Midwest territory for Western Precipitation Division, Joy Manufacturing Co. He will be in charge of all company operations for dust and fume control equipment.

N. R. (Bert) Arant resigned as technical director, Roll Manufacturers Institute, effective May 1, 1960, to take a position with The Ohio Steel Foundry Co., Lima, Ohio. **Thomas L. Kablach,** formerly of Mesta Machine Co. will succeed Mr. Arant as technical director at RMI.

A. S. Glossbrenner, president, The Youngstown Sheet and Tube Co., has been named the firm's chief executive officer in a realinement of executive functions. This title had been previously held by **J. L. Mauthe** who will continue as the company's board chairman. Mr. Mauthe is not retiring but will transfer some of his duties to the new chief executive officer.

Thomas J. McNeil was named New York District manager for the Eimco Tractor Division of The Eimco Corp. Mr. McNeil joined the Eimco organization in 1959 and was employed in market development work before assuming his present position. His territory includes the northeastern United States.

Call or Write STAMCO for...

Slitting and Coiling Lines
Cut-to-Length Lines
Flying Shear Lines
Power Squaring Shears • Automatic Re-squaring • Corrugating
Culvert • Steel Mill Equipment

STAMCO, Inc., New Bremen, Ohio

Thomas M. Elliott has been appointed superintendent of the Pittsburgh, Pa., plant of Heppenstall Co. Mr. Elliott started in the company's Personnel Department in 1951. He was promoted to assistant director of personnel in 1953 and became assistant industrial relations director in 1958.

John D. Tournaud has been appointed manager of the Detroit, Mich., district sales office of The Babcock & Wilcox Co.'s Refractories Division. Mr. Tournaud succeeds **F. B. Cornell** who is retiring. He will be responsible for the sale of all B&W refractories products in the southeast Michigan area. Mr. Tournaud has been associated with B&W since 1953, serving as refractories sales engineer in Pittsburgh and Detroit.

Joseph B. Moran has been named assistant to the director of traffic of The Colorado Fuel and Iron Corp. Mr. Moran was formerly associated with the Philadelphia Coke Division of Eastern Gas & Fuel Associates. He has had experience in sales, purchasing and industrial relations as well as in traffic control. His duties at CF&I will include co-ordination of traffic and sales.

Roger Snellman has been appointed manager of the district sales office in Detroit, Mich., by the Harbison-Walker Refractories Co. Mr. Snellman, after joining Harbison-Walker as a research engineer in 1947, entered the sales field in 1949. He was office manager of the Detroit office; then became Detroit warehouse salesman from 1951 through 1956. Since 1956, he has served as sales representative in Los Angeles, Calif.

William A. Carter has been appointed service chief at Republic Steel Corp.'s Union Drawn Steel Division plant in Gary, Ind. A veteran of 26 years of service with Union Drawn, Mr. Carter joined the company in 1934 as a machine operator at the Gary plant.

Carl E. Widell has been elected vice president in charge of marketing by the board of directors of Wagner Electric Corp., succeeding **Harold N. Felton** who will remain with the company as a vice president in an advisory and consulting capacity. Mr. Widell will be responsible for the over-all marketing activities of both the electrical apparatus and the automotive braking equipment divisions. Mr. Widell joined the Wagner company in 1940 and worked at the main office and factory in St. Louis. In 1946, he was sent to the company's Cleveland branch as a sales engineer. In 1952, he became manager of the Wagner branch in Portland, Ore., handling both the electrical and auto-

Over 50 Foxboro Consotrols are used to control pressures and flows on the Hydrogenation & Extraction Process at U. S. Steel's Clairton Works. Process is licensed by Koppers Company and Universal Oil Products with design and installation by Koppers.

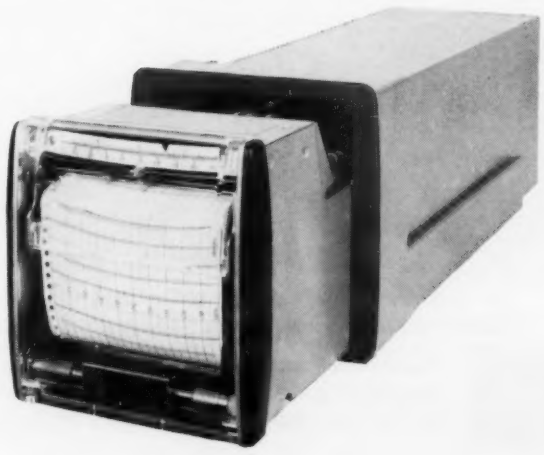
Foxboro Consotrols "doing good job" at U. S. Steel's Clairton Works

In March, 1958, a Koppers BTX Hydrogenation & UDEX® Extraction Unit — for continuous production of benzene — was installed at U. S. Steel's Clairton Works, Clairton, Pa. Foxboro Consotrol® instruments were selected for control of all pressure and flow variables on this critical process.

Clairton engineers are pleased with the good job these instruments are doing. Since the process went into operation, they report that they haven't had a single Consotrol off the panel. And the instruments give them accurate records — good controller response — both important on a critical process such as this.

Being pleased with the "good job" of their Foxboro instrumentation is typical of Consotrol users. Auto-selector . . . cascade and ratio systems . . . automatic batch control — Consotrols cover the full range of control functions. Get the complete story in Bulletin 13-18. The Foxboro Company, 585 Neponset Avenue, Foxboro, Mass. *Reg. U. S. Pat. Off.*

The pull-out feature of Foxboro Consotrol Control Stations permits Clairton instrument technicians to do all routine instrument inspection right on the panel.



FOXBORO
REG. U.S. PAT. OFF.

motive sides of the business. In 1955, Mr. Widell returned to the main office and in 1956 was made director of research and development. In 1958, he was transferred to the Marketing Division.

Henry G. Evans was elected vice president in charge of production, and **Robert N. Merk,** vice president in charge of engineering of Sharon Steel Corp. Mr. Evans began his employment with Sharon in 1933 and has held positions as foreman, plant metallurgist, blooming and bar mill superintendent, superintendent of hot strip mills, general works manager and general manager of operations.

H. W. "Chris" Christensen, retired assistant to executive vice president, U. S. Steel Corp's, Columbia-Geneva Division, has been appointed executive vice president—commercial of Fischbach and Moore Inc. Mr. Christensen had been associated with U. S. Steel Corp.'s Western operations and predecessor companies since 1920. He will headquarter at the home office of Fischbach and Moore in New York City.

Dean W. Ferguson has been appointed general foreman—galvanizing at the Pittsburgh Works of Jones & Laughlin Steel Corp. Mr. Ferguson, who was electrical engineer in the Pittsburgh Works General Maintenance Department, succeeds **Samuel A. Ambler,** who was promoted to assistant superintendent—cold strip mill and galvanizing. Mr. Ferguson has been a J&L employee since 1948, when he started as assistant general foreman in the Pittsburgh Works Electrical Department. Prior to that, he had served in various engineering positions with the General Electric Co. In 1955, he was appointed master mechanic in the Pittsburgh Works Galvanizing Department. He was named electrical engineer in 1957.

G. E. Smith was appointed as salesman in charge of the Detroit, Mich., office of Union Carbide Metals Co., Division of Union Carbide Corp. Mr. Smith formerly had served in the company's Cleveland, Ohio, district. Mr. Smith joined Union Carbide Metals in 1956.

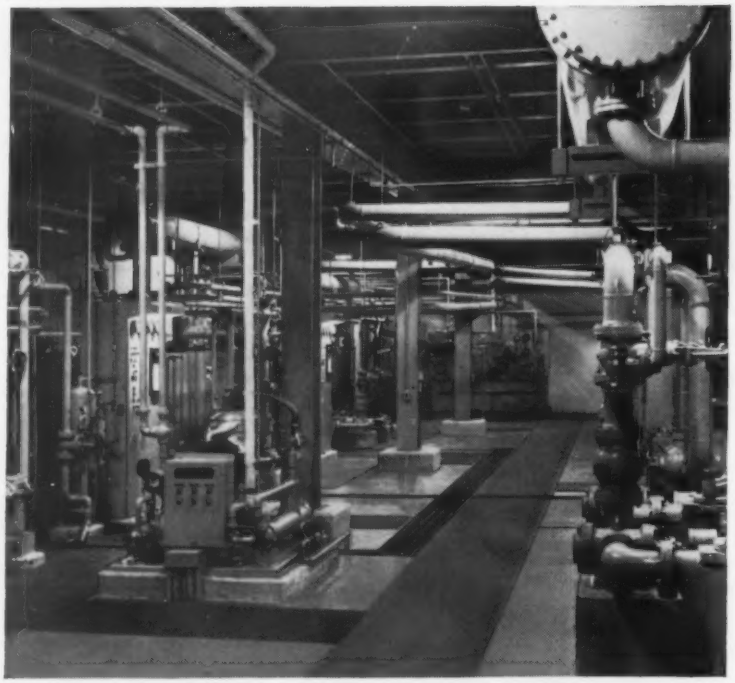
James F. Garland has been appointed corrosion engineer for A. M. Byers Co. Mr. Garland was previously associated with Rockwell-Standard Corp., as head of the analytical chemistry research and development laboratory.

Obituaries

James R. Paisley, vice president and general manager of Wean Engineering Corp. died March 2.

Carl Meyers, 68, vice chairman of the board of the Colorado Fuel and Iron Corp., died April 10. Mr. Meyers joined Carnegie Steel Co. in 1907 as a mill hand. He was superintendent of the company's McDonald, Ohio, plant from 1922 to 1932 when be became assistant district manager of the central alloy steel division of Republic Steel Corp. In 1946, he became president of CF&I. He held that position until 1952 when he was elected vice chairman.

One of the world's fastest rod mills protected by Dravo-DeLaval lubrication systems



Oil cellar at Sheffield rod mill. Designed for ease of maintenance, this installation inspires good housekeeping.

Preventive Maintenance keynoted design of the lubrication system engineered and built by Dravo for the Sheffield Division, Kansas City plant, of Armco Steel Corporation. PM is made effective, not only by automatic alarms and trouble indicators, dual reservoirs and twin filters, but also by the clean, compact layout of the oil cellar.

Five systems circulate a total of 45,200 gallons of oil at 556 gpm. There are five different viscosities and two different pressures involved. Dual reservoirs extend service life of the oil by allowing water and contaminants to settle out in the spare tank. Each of the ten tanks have automatically controlled steam heating coils, and there is a cooler for each system.

These almost maintenance-free systems were quickly and easily put in service, and required no engineering time at the site. For information on how high efficiency Dravo-DeLaval oil systems can save you time and money, write Dravo Corporation, Pittsburgh 22, Pennsylvania.

DRAVO
CORPORATION
Dravo-DeLaval
OIL SYSTEMS

DRAVO

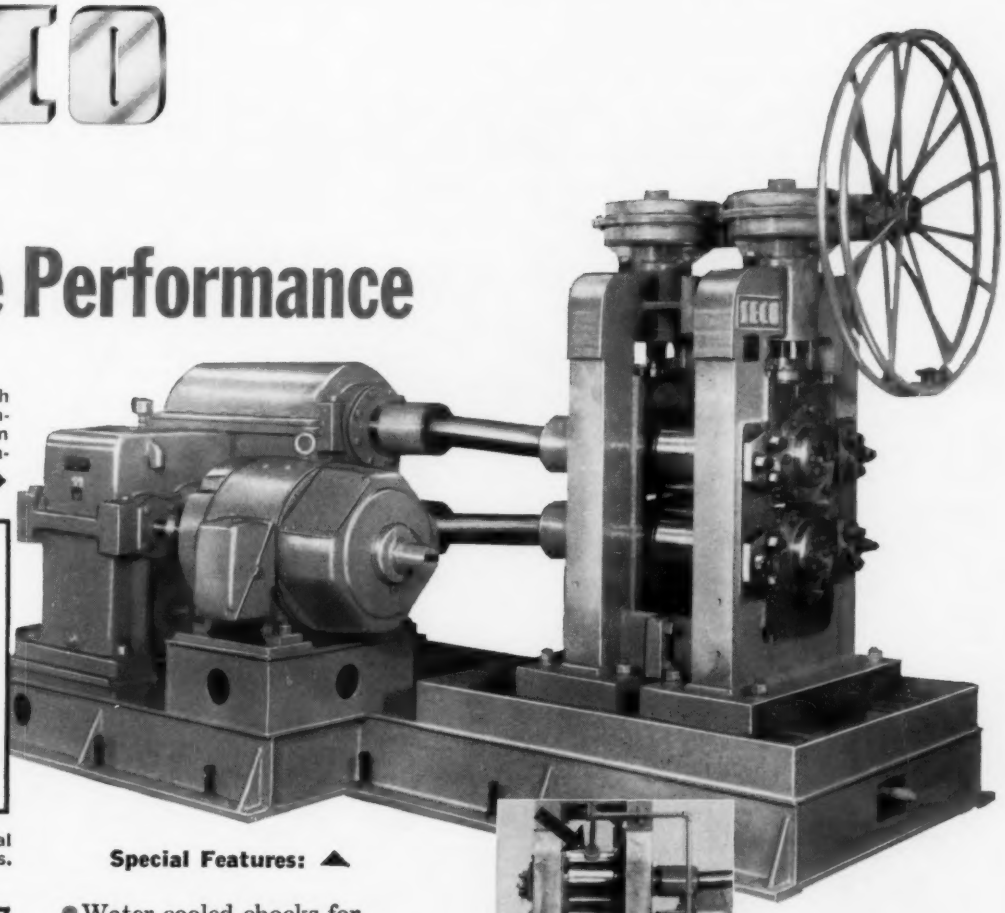
Blast furnace blowers • boiler and power plants • bridge sub-structures • cab conditioners • docks and unloaders • dredging • fabricated piping foundations • gantry and floating cranes • gas and oil pumping stations • locks and dams • ore and coal bridges • process equipment • pumphouses and intakes • river sand and gravel • sintering plants • slopes, shafts, tunnels • space heaters • steel grating • towboats, barges, river transportation

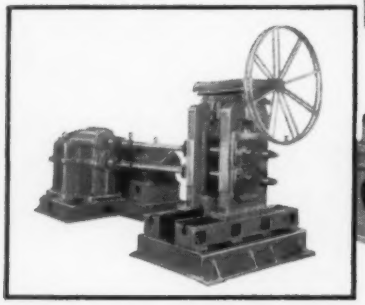
Whatever your requirements . . . SECO's staff of trained engineers can help you solve any special Mill problem you may have . . . from creative designing through installation (including *all* required auxiliary equipment).

Should your problem involve a special Cluster Mill (to accommodate either ferrous or non-ferrous metals), or a Hot Rolling Mill that bonds non-ferrous metal to a steel base . . . SECO can supply.

Custom Built HOT ROLLING MILLS *by* SECO *assures* Predictable Performance

A special, custom-built 2-high Hot Roll Flattening Mill for non-ferrous metals. (Can be built in 2 or 4-high types or a combination of both.) ▶

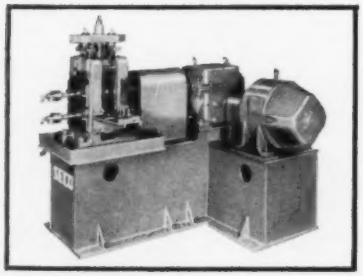




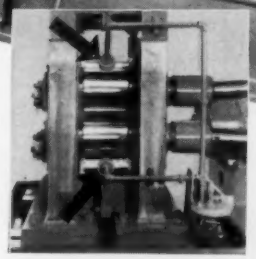
▲ A SECO designed and built Bi-Metal Bonding Mill on movable mountings.

Special Features: ▲

- Water-cooled chocks for lubrication
- 900° F. rolling temperature
- Hand wheel screw-down (adaptable for power)
- Special alloy steel rolls
- Timken Tapered Roller Bearings
- Can be built for 8, 10, 12 or 16-inch widths.



▲ A 6-inch, 2-high Wire Flattening Mill for single or tandem use.



◀ Mill is equipped with two gas jets as a means for pre-heating rolls (see arrows).

SECO

STEEL EQUIPMENT COMPANY

P. O. BOX 737, WARRENSVILLE STATION
CLEVELAND 22, OHIO

SECO STEEL MILL EQUIPMENT

- Leveling and Shearing Lines
- Combination Edging and Flattening Lines
- Tension Reels for Strip Polishers
- Narrow Strip Grinding Machines
- Slitting Lines
- Multiple Strand Pull-out Rolls and Take-up Frames
- Strip Coilers (Up and Down Type)
- Traverse Reels for Narrow Strip
- Steel Coil Up-enders
- Scrap Ballers

Affiliated with Lee Wilson Engineering Co., Inc.

3 All New electric

. . . to make

FEATURES:

- **Wide band adjustments: 0 to 500% prop. band, 0 to 100 repeats/min. reset, and 0 to 10 min. rate.**
- **Bumpless transfer even when control output is changing.**
- **Change proportional band any amount without upsetting process.**
- **Rate action circuit minimizes overshoot in batch process and during startup.**
- **Pull-out chassis for servicing without interrupting operation.**
- **Modular construction simplifies maintenance and stocking.**
- **Plug-in silicon diode rectifiers–for greater reliability.**

All three units use the same plug-in components . . . only the control output section is different. Simplifies on-the-job servicing . . . eliminates need for complicated test equipment.

3-mode control units

furnaces perform at their best

***Electr-O-Line* Control Unit**—For electronic position-proportioning control with reset and rate action

***Electr-O-Pulse* Control Unit**—For electronic time-proportioning control with reset and rate action

***Electr-O-Volt* Control Unit**—For electronic current output proportioning control with reset and rate action

One of these units—*Electr-O-Line*, *Electr-O-Pulse* or *Electr-O-Volt*—will deliver the exact kind of temperature control that's best for your furnace.

Plug-in construction is used throughout all three units—including common amplifier and power supply sections. Operator adjustments are exactly alike for all three units. Interchangeability of control output sections simplifies stocking and service problems.

Get complete details on these and other types of furnace controls from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

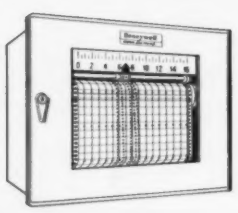
Honeywell

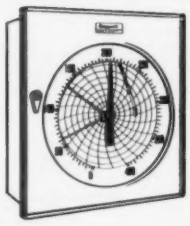
First in Control

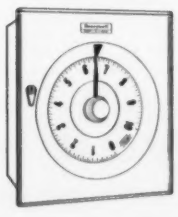
SINCE 1885

75th YEAR

PIONEERING THE FUTURE







Use *ElectroniK* strip chart, circular chart or circular scale controllers to actuate *Electr-O-Line*, *Electr-O-Pulse* or *Electr-O-Volt* units. They are integrally mounted, simplifying panel cutout and reducing wiring costs.

. . . when you use **P·G Resistors**

Adjustments to suit actual operating conditions can be made quickly by use of ample terminal connections available. If repair becomes necessary a P-G Resistor can be reassembled in your own shop with minimum effort and lower cost. These rugged, shock resistant P-G Resistors have provided low cost protection to many types of steel mill equipment for more than 25 years.

A P-G sales engineer will be glad to explain . . . in detail . . . how you can save with non-breakable Steel Grid Resistors. Write for Bulletin No. 500

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Yoder Rotary Slitters reduce inventory... speed production

To help meet the demands of tight production schedules, YODER Slitters reduce mill-width stock quickly and economically to desired widths. If your needs are as low as 100 tons per month, time and manpower savings alone will offset the cost of your YODER Slitter in a matter of months, while reducing basic inventories. Compactly designed, standard YODER Slitters are built to handle standard coil widths...completely engineered lines for special requirements.

YODER accessories, such as coil cars, swivel unloaders, scrap choppers, scrap disposers, plate levelers and coil boxes, make stock handling fast and easy.

YODER also makes a complete line of Cold Roll-Forming equipment and Pipe and Tube Mills. To profit from YODER'S years of engineering and service experience, contact your local YODER representative or send for the YODER Slitter Manual.

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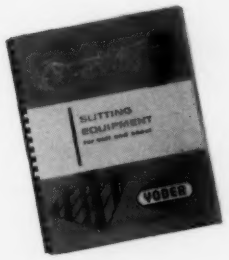
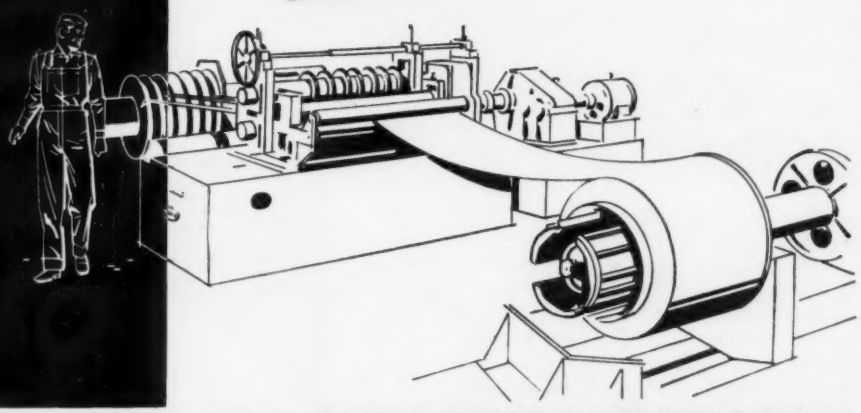


Investigate the many advantages of YODER-engineered Slitter Installations. Write today for this comprehensive, 80 page YODER Slitter Manual ... it's yours for the asking!



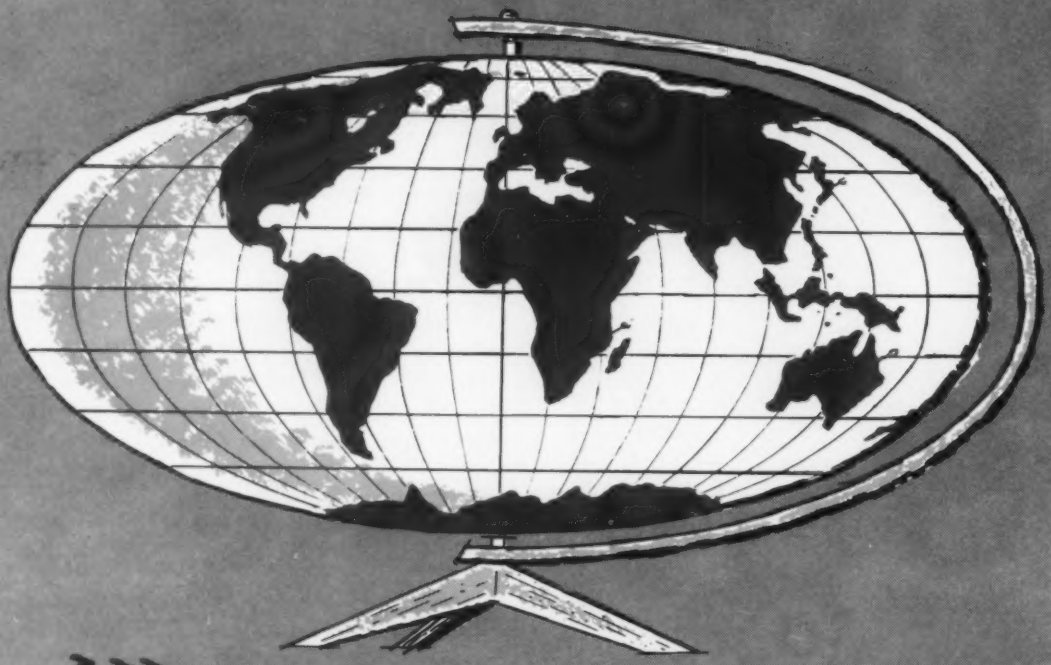
ENGINEERING **YODER** MANUFACTURING

ROTARY SLITTING LINES

PIPE AND TUBE MILLS (ferrous or non-ferrous)

COLD ROLL FORMING MACHINES

Throughout the World....



Alliance leads the way!

Alliance's same high quality workmanship is also in licensee agreements with top-flight companies building to Alliance specifications, and selling according to the Alliance standards of leadership.

A close working relationship between Alliance in America and the various licensee manufacturers assures quality, economy, dependability around the globe.

The name Alliance is a trademark wherever you go!

And insures the greatest over-all return for your investment.

"Give Us The Runway and We'll Lift The World"

Overhead Cranes * Gantry Cranes * Mill Cranes and Equipment * Hot Metal Cranes * Ladle Cranes Stripper Cranes * Soaking Pit Cranes * Soaking Pit Cover Cranes * Charging Machines * Furnace Chargers * Slab Handling Cranes * Bucket Cranes Magnet Cranes * Mold Yard Cranes * Skull Cracker Cranes * Ingot Buggies * Run-Out Tables Car Dumpers * Special Mill Equipment * Ore & Coal Bridges * Loading & Unloading Towers Forging Manipulators * Forging Cranes * Power House & Dam Cranes * Dock & Pier Handling Equipment * Research, Development & Engineering Service * Licensees & Manufacturing Facilities in Other Countries

Alliance

machine company

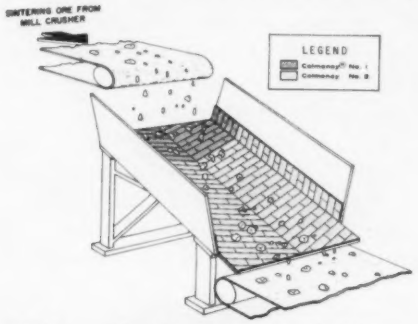
Main Office • Alliance, Ohio

Equipment News...

HARD-SURFACE CHUTES

△ Introduction of hard-surfacing to replace carbon brick lining in ore chutes brought about a 5-to-1 improvement in chute service life at a Texas steel mill.

Ore from the crusher is carried to the chute by continuous belt conveyor, as shown in the accompanying sketch. The heavy, abrasive ore is dropped onto the inclined chute,



which carries it to another belt conveyor at a lower level.

Resultant impact and abrasion in this application requires special protection for the steel plate base metal from which the chute is fabricated. Conventional practice calls for lining the bottom and a portion of the sides of the chute with carbon brick. An attempt to improve chute service life and cut maintenance costs led to the use of hard-surfacing techniques.

Hard-surfacing alloys for the ore chute application were selected first on the basis of duty and second on the basis of economy. Colmonoy No. 1 electrode was selected for the area in the upper one-quarter of the chute; Colmonoy No. 2 electrode was selected for the lower three-quarters of the area (see sketch).

The hard-surfacing overlay is applied in a brick-herringbone pattern. The electrodes are applied by d-c electric arc welding, reverse polarity, using the "skip welding" method, whereby the welder runs a 4- or 5-in. bead, then "skips" to another location to minimize the heat effect on the base metal. It is this technique that gives the alloy deposit its brick-like appearance.

The resultant welded overlay provides a surface hardness of 58 to 63 on the Rockwell "C" scale for the Colmonoy No. 1 and 50 to 55 RC for the Colmonoy No. 2. When the chute has finally worn excessively, it need not be scrapped since reclamation is easily performed using the same hard-surfacing materials and techniques.

A-C CONTACTOR

△ A new 600-ampere a-c contactor (Type GP) for a-c electric circuits is offered by the Westinghouse Electric Corp. The contactor has an a-c operating magnet and is insulated for a maximum of 600 volts. Designed for continuous duty, the a-c coils operate the contactor at 85 to 110 per cent of rated coil voltage.

Featuring small size and a-c operation, the new unit can be mounted on steel and is available in two- or three-pole, front- or rear-connected assemblies, with or without arc quenchers.

A permanent air gap is built into the new structure to provide sufficient reluctance in the magnetic path to insure a positive dropout on de-energization. The air gap is so situated that the hammering resulting from operational impact will not decrease the amount of air gap.

In addition, the moving armature is flexibly supported and is capable of self-alinement as it closes against the stationary magnet.

SLING HOOK

△ The S. G. Taylor Chain Co., Inc., has introduced a new Tayco Sling Hook No. A-75 for use with 1¼ and 1⅜ in. diam alloy chain. The

LINK-BELT TO MARKET BUCKET WHEEL EXCAVATORS

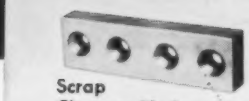
Link-Belt Co. has acquired sales rights in the United States and Canada for LMG bucket wheel excavators made in Western Germany by Orenstein-Koppel and Lubecker Maschinenbau A.G. Bucket wheel excavators are made in a wide range of sizes but are particularly suited to high capacity operation—some handle up to 13,000 cu yd per hr (nearly 300 sixty-ton coal cars). The bucket wheels dig continuously, delivering the excavated material from their discharge boom belts in a relatively uniform flow. For this reason the belt conveyor systems beyond the excavators can be narrower and less expensive than would be required for the same average capacity from intermittent type excavators with their high peak loads. Thus, the inherent economies of belt transportation are improved with the use of bucket wheel excavators.

COWLES

slitting knives and special purpose metal working tools

● Complete line of slitting and trimming knives in our job-proved **Max-Cut, Specialloy, Superalloy, Circle C** and **Super C** grades for slitting any high or low carbon, stainless, silicon or non-ferrous material. Complete range of sizes. Prompt delivery. Also carbide rimmed knives. Our precision manufacture and exacting heat treatment assure sharp, clean cuts; and long, dependable service with only infrequent downtime for re-grinding. Wide experience in designing and manufacturing Chopper Blades, Roll Forming tools and other special purpose tools for a wide variety of metal working operations.

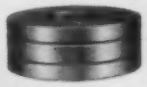
Specify "Cowles" rotary knives and special tools for every job. They'll make your work easier—and cut your costs.



Scrap Chopper Blade

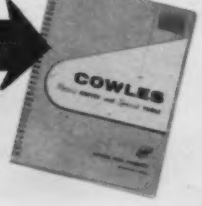
Roll Forming Tool

Roll Turning Plugs



Grooved Edging Roll

Get full details. Write for Bulletin No. 571 Today.



COWLES TOOL COMPANY

2086 WEST 110th STREET • CLEVELAND 2, OHIO

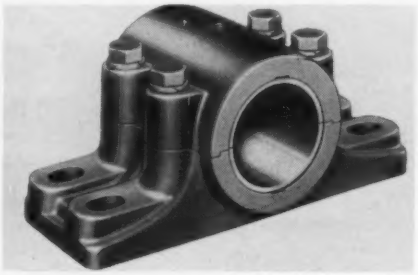
hook is drop-forged from alloy steel and heat treated. Its patented I-beam type design assures extra strength and provides a safe gripping area for the hooker. Company engineers report that the hook will not bend, even when the load is applied at the point, providing that the working load limit (of the chain for which it is designed) is not exceeded.

Side bending is greatly reduced. Resistance to shock, work-hardness and grain growth is increased. Other features include a larger eye to accommodate shackle pins and wire rope thimbles, and a wider, deeper throat.

PILLOW BLOCK

△ Bronze precision liners can be replaced quickly and easily in pillow blocks of a new design announced by Dodge Manufacturing Corp.

The new sleeve bearings are recommended for applications where shock loads, elevated temperatures and corrosive conditions are anticipated. It is possible to replace a



worn bushing, or liner, without removing the bottom half of the housing from its support. The change is accomplished simply. Only the cap of the block is removed—the shaft is lifted just enough to permit the lower half of the liner to be loosened and slipped out. A new bronze liner can then be inserted and seated by tapping lightly. The cap liner can also be replaced very easily.

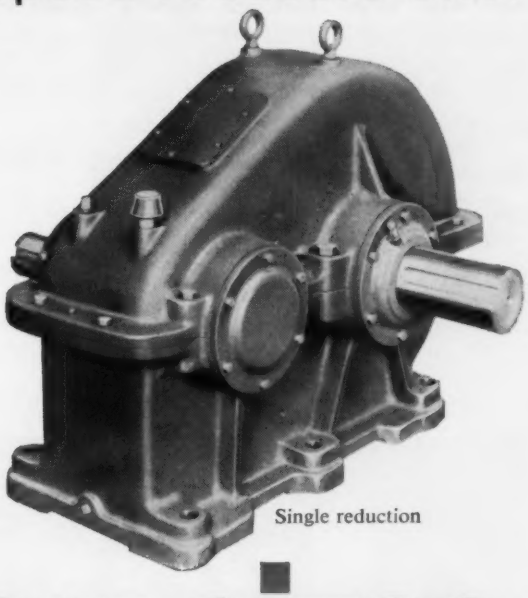
No screws are required—rotation of the liner with the shaft is prevented by a brass retainer spool recessed between cap and base of the housing.

The bronze-bushed line includes split journal bearings (two-bolt) for standard power transmission shaft sizes from $1\frac{15}{16}$ to $2\frac{15}{16}$ in., rigid pillow blocks (four-bolt) for shafts from $3\frac{7}{16}$ to 8 in., and angle pillow blocks for all standard transmission shafts.

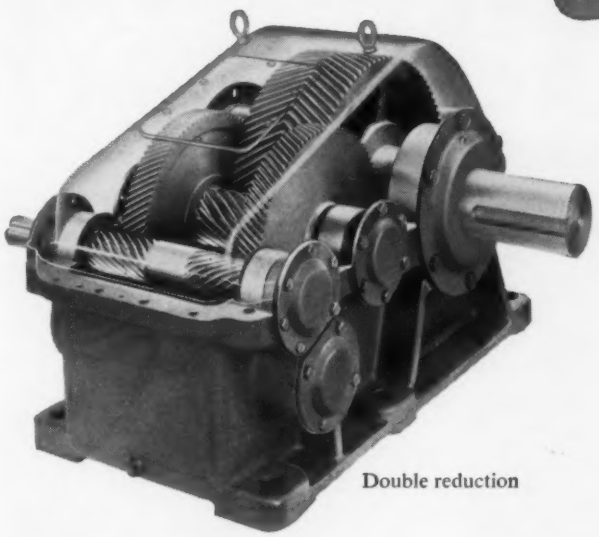
Semisteel housings have tongue-

NOW Link-Belt parallel shaft speed reducers offer

new design



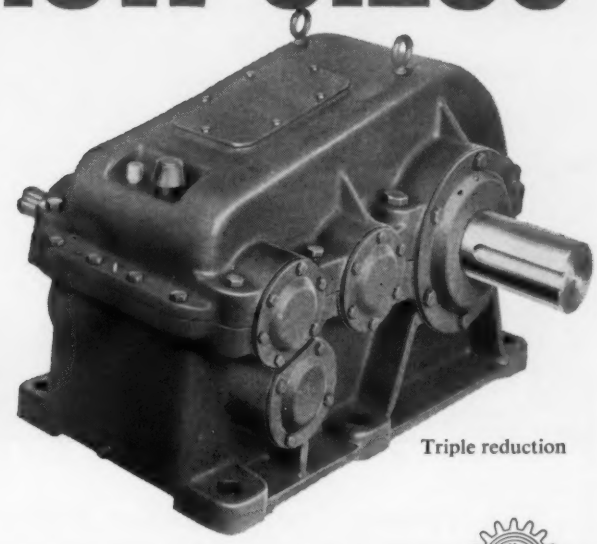
Single reduction



Double reduction

new sizes

new ruggedness



Triple reduction

reduce drive costs by matching drive size to horsepower requirements with 35% more sizes

New design—Herringbone or double helical gears arranged in new "balanced" design permit high horsepower, high ratio reduction in a sturdy, compact housing.

New sizes—Now 18 sizes each of double and triple reduction units; 17 single. Drive selections closely match hp requirements, with a corresponding reduction in drive costs. Available to 2800 hp, ratios to 292:1.

New ruggedness—Rigid, ribbed housing keeps parts accurately and permanently aligned even under grueling operating conditions involving heavy shock loads, and temporary overloads.

For complete information call your nearby Link-Belt district sales office or authorized stock-carrying distributor. Ask for Book 2719.

OUTSTANDING FEATURES

- Grease-lubricated seals.
- Positive splash lubrication supplies ample flow of oil to all moving parts.
- High-capacity spherical roller bearings for maximum loading.
- Gears of hardened, precision alloy steel. Double helical or herringbone design.
- New, built-in backstop.
- Exceptional wearing qualities in accurately machined low-speed shafts of heat-treated carbon steel; intermediate shafts of chrome-molybdenum steel.
- Cast iron housing maintains permanent, accurate alignment of all parts.

LINK-BELT

SPEED REDUCERS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15,364

and-groove joints in four-bolt base sizes and fitted bolts in smaller sizes to prevent cap shifting. Ductile iron housings may be obtained on order. Bushings are machined from high grade cast leaded bronze alloy. Liner tops are drilled and grooved to admit grease or oil and distribute it evenly throughout the bore. Accurate machining insures precision fit on the shaft. Bearing ends are precision machined to take thrust.

Designed for heavy-duty service, the bronze-lined blocks will withstand elevated temperatures, relatively high shaft speeds, shock and pressure. Liners made of other alloys can be furnished on order for especially difficult heat conditions.

SHEET-BILLET LIFTER

△ A combination sheet and billet lifter has been developed by The Hill Acme Co. to handle single sheets, slabs, billets or ingots. Multiple vacuum cups or scissors tongs are used as required.

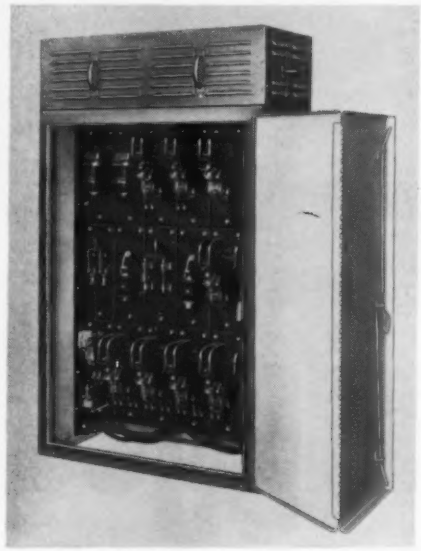
The tong action is automatic and the face of the material being handled is protected by supporting rollers attached to the tong arms.

The frame supporting the vacuum cups is actuated by air cylinders controlled by a solenoid valve and the lifter incorporates its own vacuum system including motor, pump and vacuum reservoir.

These unique lifters are ideally suited for handling nonferrous materials as well as ferrous metals and are made in sizes and capacities to fit customer requirements.

CONTROLLER

△ A d-c crane hoist controller which operates on a-c power is available from the EC&M Division of Square D Co. The controller, called the Form HWR, employs efficient static rectifiers to supply d-c power to a



series-wound motor and its series-wound brake. This arrangement, because of the inherent "blocking" characteristic of the rectifiers, automatically increases motor stability for safe lowering of extreme overloads.

The HWR controller is simple to maintain. Youngstown limit stops provide positive over-hoisting protection, and no load-retarding or load-indicating devices are required.

STENCIL UNIT

△ Northeast Ohio Machine Builders, Inc., has announced an automatic stenciling machine.

Completely automatic, the new machine stencils combinations of required information, such as size, length, class, weight per foot,

The revolutionary Bliss Pulsation Burner

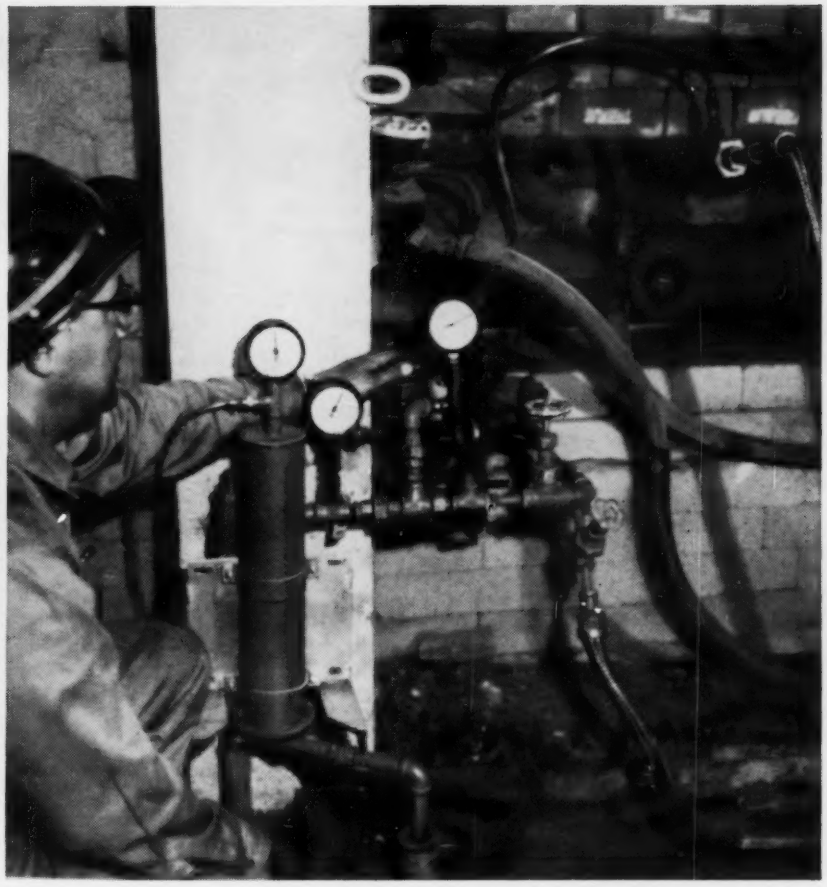
produces temperatures never before achieved with oil or natural gas.Burning oil, it can reach a searing 3450°F. On 1000 BTU/cu. ft. natural gas, it develops 3320°F. Both these extremely high temperatures are close to the theoretical limits for these two fuels. Foundries, smelters, heat treaters and other metal processers have been quick to take advantage of the remarkable combustion efficiency of these new burners. To them, it has meant faster heating cycles, cleaner flue gases, and above all, fuel economy that cuts from 12% to 30% from their furnace overhead. Not to speak of reduced maintenance on refractory linings.

To learn how the Bliss Burner can increase the heat output in your plant while it's saving you money in fuel and furnace maintenance, write today for our Bulletin No. 60. It's yours for the asking.

BLISS
SINCE 1857

E. W. BLISS COMPANY
Canton, Ohio
BLISS is more than a name—it's a guarantee

O_2 Analyzer at Pittsburg, Cal. Works



Exclusive L&N Steam Jet Sampling System

New Trend in Open Hearth Combustion Control

Columbia-Geneva modernizes with continuous O_2 analysis

As fast as budget and operating conditions permit, open hearth furnace operators are switching to accurate, dependable Leeds & Northrup Oxygen Analyzing and Control Systems for improved O-H combustion practice. At over 70 installations, superintendents are anticipating increased roof life, lowered fuel costs and shorter heats.

Typical of complete installations of this industry-proved equipment are those at three plants of Columbia-Geneva Steel Division, United States Steel Corporation. There, 19 L&N systems have been in operation, some since early 1957, providing automatic control of exit gas O_2 content . . . speeding heats and lowering Btu requirements.

These systems operate directly from Leeds & Northrup Magnetic Oxygen Analyzers. Continuously sampling the oxygen content of waste gas, the Analyzers supply a signal to Speedomax® recorder-controllers. The control systems, in turn, operate to adjust louvers on the forced air fan, or control fuel directly to maintain the desired oxygen content in the waste gas.

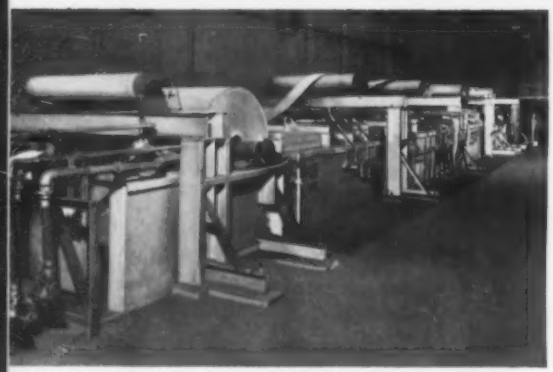
And at all installations, the L&N Magnetic Oxygen Analyzing equipment is providing a stable, accurate measurement, fully compensated for background gases, without flammable auxiliary gases. The exclusive L&N Steam Jet Sampling feature assures that a clean sample is continuously delivered under pressure to the Analyzing Unit.

Ask your nearby L&N engineer about this important trend in open hearth combustion practice. He can give you facts and figures about how others have profited from this equipment. Call him, or write 4942 Stenton Avenue, Philadelphia 44, Pa.

LEEDS & NORTHRUP
Instruments — Automatic Controls • Furnaces

ANNEALING STAINLESS in a "natural" curve...

COLD ROLLED
STRIP ANNEALING
FURNACE FOR 48" STRIP



OVE: SALT DESCALING BATH. BELOW: HOT ROLLED STRIP LINE.

*A Catenary curve, that is...

...the natural path assumed by the strip as it passes through the continuous Annealing Furnace. Complete exposure of the strip surface to heat and furnace atmosphere and the uniform stress throughout the strip assure maximum product uniformity. Support of the strip by special soft compressed asbestos disc rolls located outside the ends of the furnace assures an unmarked surface.

STAINLESS STEEL HEAT TREATING SPECIALISTS

The support of the strip on special rolls and the proper application of thermal conditions are but part of the engineering technique and heat treating experience that enter into the design of Drever Stainless Strip Annealing and Descaling Lines. Keeping pace with the ever growing demand for heat treatment of stainless steel in all its forms has been a particular project at Drever. This specialization is reflected in the number of successful installations, in many sizes, now in operation.

DREVER ENGINEERING FOR YOU

The widening industrial and commercial use of stainless steel and the higher quality standards point up the need for producers to study the latest methods of heat treatment. Consult with our engineers regarding your requirements—or ask for Bulletin B-81. Drever Company, Bethayres, Pa. Phone: Wilson 7-3400.

DREVER INDUSTRIAL FURNACES

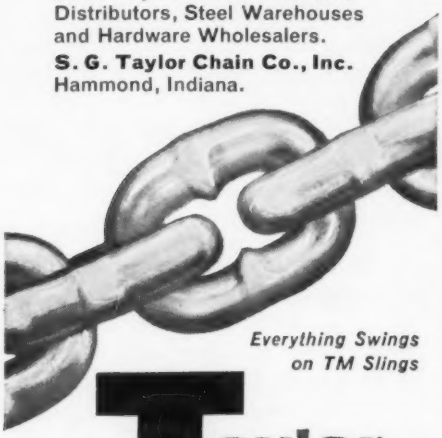
ENGINEERED TO YOUR PARTICULAR REQUIREMENTS

ENGINEERING AND MANUFACTURING FACILITIES AROUND THE WORLD THROUGH ASSOCIATES IN FRANCE, GREAT BRITAIN, GERMANY, ITALY AND JAPAN

TOPS *in* STRENGTH

TM Alloy Chain is used wherever rugged "brute strength" is a requisite. For example, the working load limit of ¾" TM Alloy is 23,000 pounds. It's tougher, safer and far less costly than other grades of chain tested. Order to your specifications. Available everywhere from Industrial Distributors, Steel Warehouses and Hardware Wholesalers.

S. G. Taylor Chain Co., Inc.
Hammond, Indiana.



Everything Swings on TM Slings

Taylor Made CHAIN SINCE 1873

ASTM or API specifications, date, tests and other pertinent data on double random, 21 ft 0 in. uniform, single random, black, galvanized, reamed and drifted, plain end, threaded and coupled pipe. Bars may be marked in the same manner.

Pipe handling is completely automatic from entry skids to discharge point by means of walking beams operating from a variable drive with a 4 to 1 speed range. Stenciling operation is interlocked with the pipe handling and is accomplished by traveling spray guns mounted at a proper height above brass stencils to minimize overspray.

CONVEYOR CARRIER

△ Stephens-Adamson Mfg. Co. has developed a new catenary conveyor carrier which provides true catenary suspension for the conveyor belt under all load conditions.

The "Flexiroll" carrier features a high tensile spring steel "dead shaft" to which is mounted a mild steel trunnion and a shock absorbing compression spring. The shaft has an initial set providing a trough which enables the most rigid of belts to make

contact with the face of all rollers when the belt is running under all load conditions. Consequently, the carrier supports the belt in a natural arc contributing to more efficient belt training and reduced belt wear.

The unit incorporates many desirable design features to provide greater efficiency and less maintenance in conveyor operation. The carrier rollers resist reaction to corrosive, abrasive, greasy, oily and combustible materials. Natural flexing action of the carrier reduces material breakage, spillage and material build-up.

The all steel jig welded frame is self-cleaning as is the roller assembly.

Greater strength than conventional catenary carriers is provided through the use of the solid spring steel shaft rather than a steel cable which is subject to breakage through constant flexing action.

The carrier is available for 18, 20, 24, 30 and 36 in. belt widths.

VALUE ENGINEERING PROVES

ROCKWELL *Resilient-Seated* Butterfly Valves *STAND OUT*

- Weigh Less—Cost Less
- Need Less Space
- Easier to Install
- Always Operable
- Low Pressure Drop
- No Fouling
- Negligible Maintenance
- Simplified Control —Manual or Remote

Bodies lined with any elastomer—from natural rubber to Viton.
Construction of any metal.
Operates from simple lever to automatic and remote control. No limit in size.
Let Bulletin 590X help you put value engineering to work on your valve applications. Just mail the coupon below.

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2360 Eliot St., Fairfield, Conn.

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SUBSTATIONS

△ A new line of ultra-compact, packaged electrical substations which slash over-all size and floor space requirements—by as much as 53 per cent in size, 40 per cent in floor area—has been introduced by I-T-E Circuit Breaker Co.

The new substations—a move toward greater compactness and standardization—are an expansion of I-T-E's line of Tranfo-Units. The new units combine high- and low-voltage control and protection equipment with a dry type power transformer in a single, integrated assembly.

The substations will be built in quantity lots and will be virtually off-the-shelf items to provide a high degree of compatibility with the marketing procedures of electrical distributors throughout the country.

Available in ratings from 75 through 500 kva, the line will augment I-T-E's standard line of Tranfo-Units which are produced in sizes from 45 through 2500 kva, primary voltages through 14.4 kv and secondary voltages through 600 volts.

Class H, ventilated dry type transformers for new Tranfo-Units can be specified with these options of power and voltage ratings:

Kva	75, 112.5, 150, 225, 300, 500
High voltage	480, 2400, 4160, 4800 volts
Low voltage	208 wye/120, 240, 480 wye/277, 480

The high-voltage section can be supplied with a choice of air terminal chamber, fused or unfused interrupter switch, or oil fuse cutouts. The top or bottom of the section compartment may be used for cable entrance.

The low-voltage section can consist of either a convertible power panelboard or a lighting panelboard, incorporating I-T-E's molded case circuit breakers.

Panelboards can be provided with or without a main circuit breaker. Kirk key interlocks can be incorporated for protection of personnel and equipment. When metering is required, a separate end compartment can be added which also permits further addition of extra molded case circuit breakers.

The BLOOM Time-Cycle Reversal Unit

assures FULL, FAST AND EFFICIENT REVERSAL OF REGENERATIVE FURNACES AUTOMATICALLY

This complete, compact, factory-tested unit provides a combination electric-pneumatic system for Open Hearth Furnace and Soaking Pit reversal. It eliminates reversal puffing and shortens reversal period. (10 to 15 seconds easily accomplished).

Shorter reversal cycle improves furnace life.

These units have been in continuous service for nine years. Trouble-free maintenance.

WRITE or phone for complete information on the Bloom Time-Cycle Reversal Unit.

BLOOM ENGINEERING CO., INC.
837 W. North Avenue Pittsburgh 33, Pa.

Book Reviews

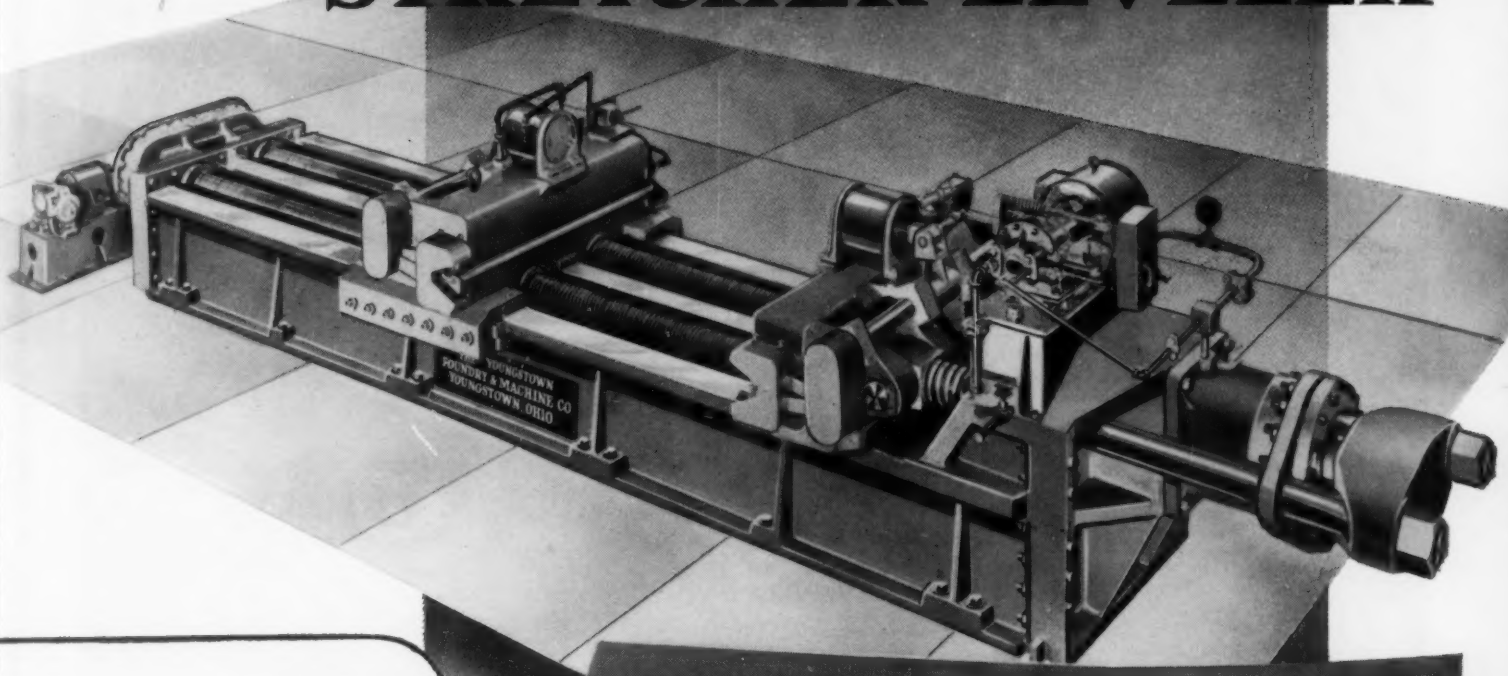
"Part 1. Ferrous Metals Specifications" of the "1959 Supplements to book of ASTM Standards (including Tentatives)" has been recently published by the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa. The book contains 362 pages, 6 × 9 in., bound in heavy paper cover and sells for $4.00. This book contains 58 standards on steel pipe, tubes, castings, bolting materials, boiler plates and rivets, sheet and strip, bars, forgings, chain, corrosion and heat-resisting steels, also forged or rolled pipe fittings and welding fittings, structural and rivet steel, coated steel and iron products, wrought iron, cast iron, ferro-alloys and titanium alloys.

"Electronic Computers Principles and Applications" (second edition), by T. E. Ivall has been published recently by Philosophical Library, 15 East 40th Street, New York 16, N. Y. The book contains 260 pages, 6 × 9 in., is cloth bound and sells for $15. The treatment of this edition has been made as general as possible providing a broad back ground picture of the whole computing field. The book is intended as a nonmathematical introduction to

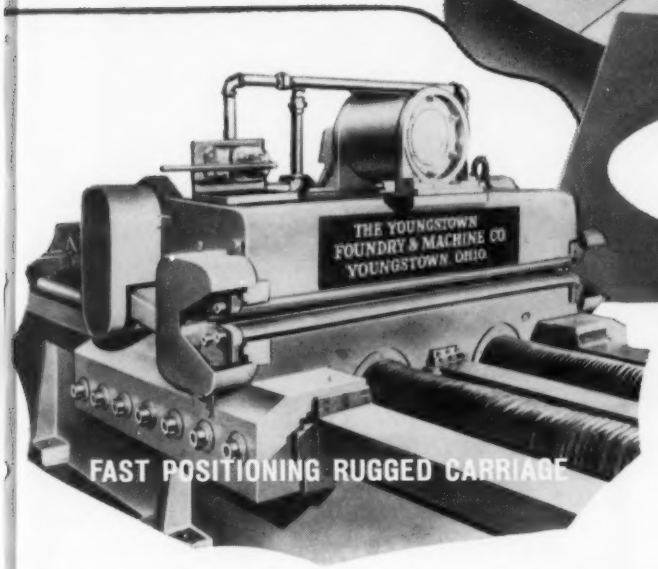
"YOUNGSTOWN"

New Carriage-Type Design

STRETCHER LEVELER



a small difference in design makes a big difference in RESULTS...



FAST POSITIONING RUGGED CARRIAGE

CONSERVES VALUABLE FLOOR SPACE
SPEEDS STRETCHING OPERATION
AIDS QUALITY CONTROL

WEDGE TYPE HEADS with WAFFLE TYPE GRIPPER JAWS assure flatness of sheet-ends.

Rugged Three Way fabricated Steel Bed insures utmost rigidity.

The Hydraulic Stretcher Leveler pictured is 800,000# Capacity capable of stretcher leveling mild cold rolled sheets 30″ to 62″ wide, 30″ to 168″ long, up to .180″ thick in either single or multiple sheets.

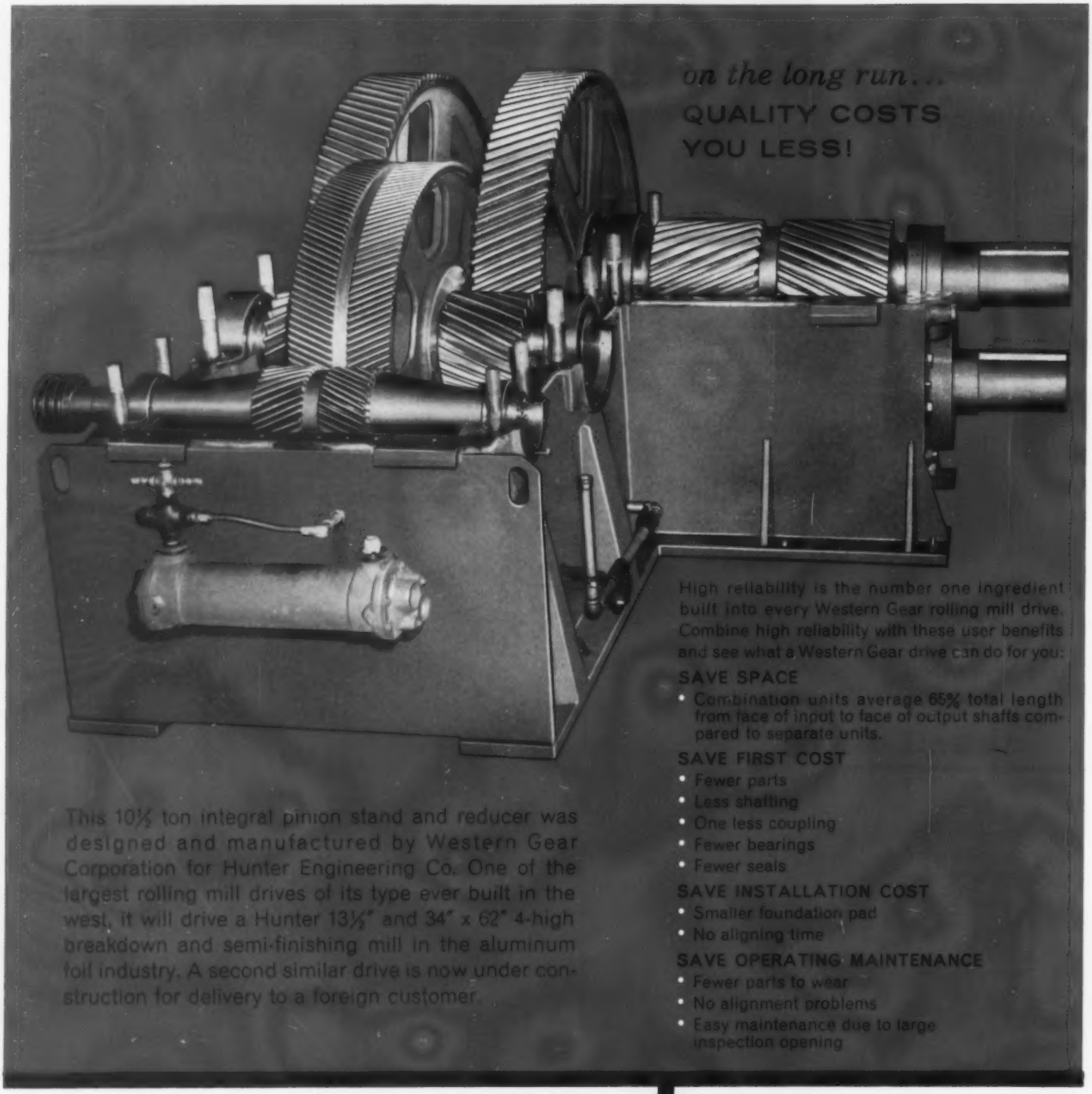
A complete range of sizes . . . built from 10,000# for aluminum extrusions to 2,000,000# for stretching plate. New performance throughout a long life of service is assured by traditional "YF&M" rugged construction.

Write for Complete Information.

The Youngstown Foundry & Machine Company

Serving Industry Since 1885

Youngstown 1, Ohio



on the long run...
QUALITY COSTS YOU LESS!

This 10½ ton integral pinion stand and reducer was designed and manufactured by Western Gear Corporation for Hunter Engineering Co. One of the largest rolling mill drives of its type ever built in the west, it will drive a Hunter 13½" and 34" x 62" 4-high breakdown and semi-finishing mill in the aluminum foil industry. A second similar drive is now under construction for delivery to a foreign customer.

High reliability is the number one ingredient built into every Western Gear rolling mill drive. Combine high reliability with these user benefits and see what a Western Gear drive can do for you:

SAVE SPACE
- Combination units average 65% total length from face of input to face of output shafts compared to separate units.

SAVE FIRST COST
- Fewer parts
- Less shafting
- One less coupling
- Fewer bearings
- Fewer seals

SAVE INSTALLATION COST
- Smaller foundation pad
- No aligning time

SAVE OPERATING MAINTENANCE
- Fewer parts to wear
- No alignment problems
- Easy maintenance due to large inspection opening

W

INDUSTRIAL PRODUCTS DIVISION

WESTERN GEAR CORPORATION

Contact the Western Gear representative in your city or write, wire or phone:

WESTERN GEAR CORPORATION
Industrial Products Division
P.O. Box 126 · LYtel 3-7611
Belmont, California

OTHER WESTERN GEAR POWER TRANSMISSION PRODUCTS

Integral gearmotors | Parallel shaft reducer | Vertical shaft reducer | High speed unit | Right angle reducer

CANCER CAN BE CURED

More than one million Americans are living proof. Remember...your contributions helped save many of these lives. Your continuing contributions are needed to help discover new cures and, ultimately, the prevention of cancer itself.

Remember, too, if you delay seeing your physician, you drastically cut your chances of cure. Annual checkups are the best way of detecting cancer in time.

Guard your family! Fight cancer with a checkup & a check

American Cancer Society

the principles and applications of computers employing valves, transistors and other electronic devices. The bulk of the book is devoted to describing the circuitry and construction of both digital and analog computers; it outlines also their rapidly developing applications in industry, commerce and science with emphasis placed on the application to "automation" or "control" techniques in industry as well as on computing techniques applied in research and design work. Developments since the first edition (1956) have been so rapid that this second edition has been almost entirely rewritten, new material has been added, dealing respectively with analog computer circuits, the programming of digital computers and the evolution of the more "intelligent" machines of the future. The diagrams have been replaced by new ones, and pictures of more modern electronic computer equipment are used.

"Dictionary of Atomic Terminology" (English-German-French-Italian) by Lore Lettenmeyer has been published recently by Philosophical Library, Inc., 15 East 40th St., New York 16, N. Y. The book contains 298 pages, 6 × 9 in., is cloth bound and sells for $6. This dictionary provides a selection of the essential scientific and technical terms employed in connection with atomic and nuclear physics, reactor engineering, radiation physics and associated fields to facilitate the study of the relevant foreign literature on the subject. In the main section, expressions are arranged alphabetically in English, with German, French and Italian equivalents. Each expression is numbered. German, French and Italian index sections (arranged alphabetically) are provided with equivalent number shown.

"Mechanical Properties of Intermetallic Compounds," edited by J. H. Westbrook has been published recently by John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. This work is based on a symposium held in Philadelphia, Pa., May, 1959, sponsored by the Electrothermics and Metallurgy Div., of The Electrochemical Society, Inc. This book is the first and only explicit treatment of the mechanical properties of intermetallic compounds. Within the frame-

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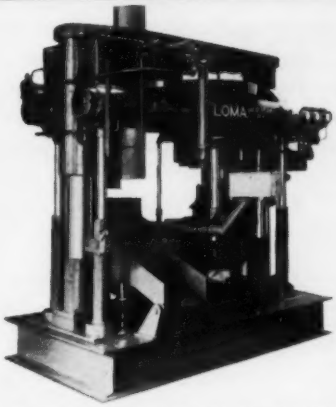

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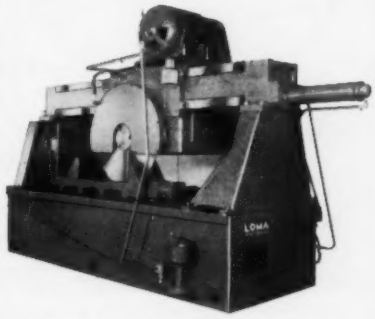

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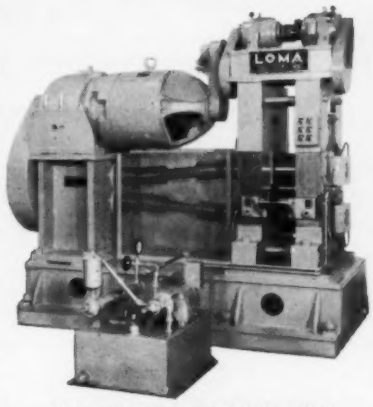

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work of the symposium theme, a broad coverage of subject matter is represented, including discussions portraying phenomenon of the mechanical behavior of intermetallics; theoretical and experimental investigations of particular properties; experimental techniques for the preparation and study of intermetallics and extensive review of the literature. The book is liberally illustrated by use of line drawings, charts, graphs, equations and actual photographs.

"Malleable Iron Castings" has been recently published by the Malleable Founders Society, 781 Union Commerce Building, Cleveland 14, Ohio. The book contains 526 pages, 6 × 9 in. is cloth bound and sells for $10. The contents of this handbook have been expanded more than 40 per cent over the previous edition, published in 1944. New emphasis has been given to the description of pearlitic malleable iron. Machinability is given extensive detail and covers the discussions of all the basic operations: turning, drilling, boring, milling and tapping. Case histories are given and illustrations included for each operation in the processing sequence; data such as tool feeds and speeds, rake angles, etc. The handbook is designed to help in the design of metal components, material selections, and processing malleable castings. The book is profusely illustrated by use of actual photographs, graphs, charts and tables.

"Part 3. Methods of Testing Metals (Except Chemical Analysis)" of the "1959 Supplement to Book of ASTM Standards (including Tentatives)" has been recently published by the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa. The book contains 110 pages, 6 × 9 in. and sells for $4.00. The book contains 14 standards for tests for mechanical properties, effect of temperature, corrosion, electrical and magnetic properties. Also included are nondestructive testing and sampling methods.

"Tin and Its Alloys," edited by E. S. Hedges with the collaboration of J. W. Cuthbertson, E. C. Ellwood, W. E. Hoare and W. R. Lewis, has been published recently by Edward Arnold (Publishers) Ltd., and is available from St. Martin's Press, Inc., 175 Fifth Avenue, New York 10, N. Y. The book contains 424 pages, 7½ × 10 in., is cloth bound and sells for $27.50. The book confines itself to the properties and applications of tin and its alloys. The book thoroughly discusses tin itself whether as pewter, foil, collapsible tubes, organ pipes or tombs. There is a scientific account of the physical and mechanical properties of tin, its chemical behavior is discussed; the electrodeposition of tin and its alloys is covered; hot tinning and tinplate are handled from a chemical and practical metallurgical outlook, and practical metallurgy prevails through the portion of the book devoted to applications of tin in the alloy field. The book maintains a useful balance of theory and practice, is well illustrated. Actual photographs, tables, graphs, charts, etc., are used.

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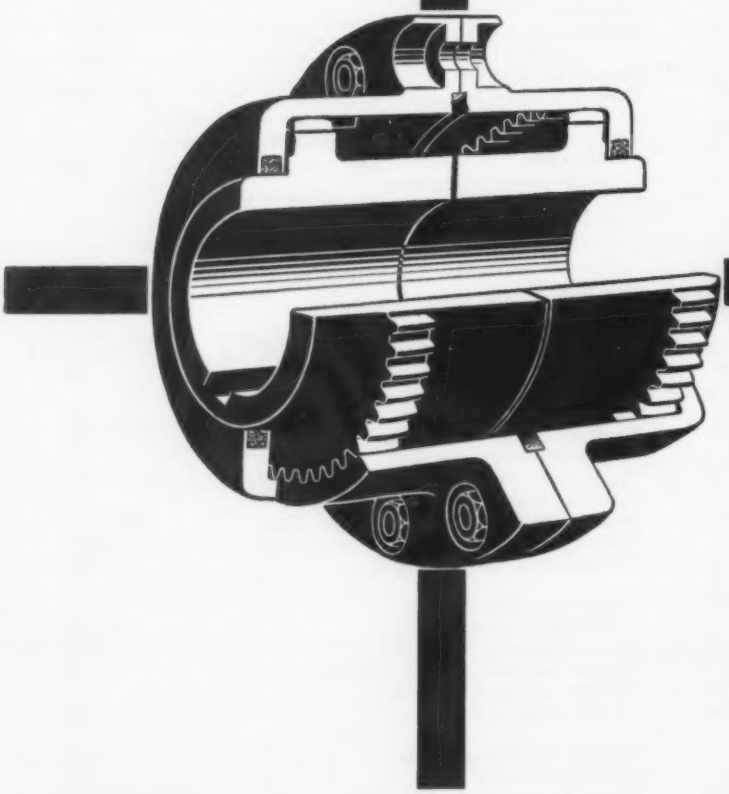

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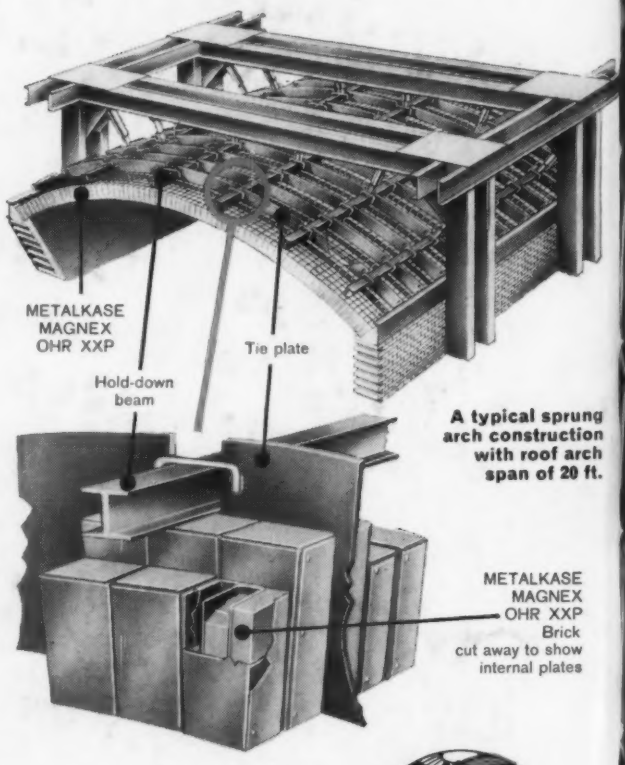

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